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THE ELEMENTS

OF

STRUCTURAL BOTANY

WITH SPECIAL REFERENCE TO THE STUDY

OF

CANADIAN PLANTS,

TO WHICH IS ADDED

A SELECTION OF EXAMINATION PAPERS.

BY

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NOTE.—In explanation of the omission of Professor Macoun's name from the title page of the present edition, the Publishers desire to say that the original design of the authors was to prepare jointly a work on the Canadian Flora, Mr. Spotton to write and illustrate an introductory volume, and both parts, for the sake of uniformity, to bear the names of both authors. Owing to Professor Macoun's engagement with the Dominion Government, the joint scheme was necessarily abandoned, and the whole work (the second part of which is now in the press) will henceforth be issued under Mr. Spotton's signature only.

PREFACE.

The work, of which the present little volume forms the first part, has been undertaken, at the suggestion of several eminent educationists, to supply a palpable want. The works on Botany, many of them of great excellence, which have found their way into this country, have been prepared with reference to climates differing, in some cases, very widely from our own. They consequently contain accounts of many plants which are entirely foreign to Canada, thus obstructing the search for descriptions of those which happen to be common to our own and other countries; and, on the other hand, many of our Canadian species are not mentioned at all in some of the Classifications which have been in use. It is believed that the Classification which is to form the second part of this work will be found to contain all the commonly occurring species of the Provinces whose floras it is designed to illustrate, without being burdened with those which are either extremely rare, or which do not occur in Canada at all.

The present Part is designed to teach the Elements of Structural Botany in accordance with a method which is believed to be more rational than that commonly adopted; and it will be found to supply all that is requisite for passing the examinations for Teachers' Certificates of all grades, as well as any others demanding an elementary knowledge of the subject. It contains familiar descriptions of common plants, illustrating the chief variations in plant-structure, with a view to laying a foundation for the intelligent study of Systematic Botany with the aid of the second part; then follow a few lessons on Morphology; and the

Elements of Vegetable Histology are treated of in as simple and brief a manner as was thought to be consistent with the nature of the subject.

The Schedules, the use of which is very strongly recommended, were devised by the late Professor Henslow, of Cambridge University, to fix the attention of pupils upon the salient points of structure. They will be found invaluable to the teacher as tests of the accuracy of his pupils' knowledge. The cost of striking off a few hundred blanks of each sort would be very trifling, and not worth considering in view of the resulting advantages.

The wood-cuts are from drawings from living specimens, except in two or three instances where assistance was derived from cuts of well-known excellence in standard works on Botany. It need hardly be said that the engravings are not in any sense intended to take the place of the living plants. They are designed chiefly to assist in the examination of the latter, and whilst it is hoped that they may be of service to those who may desire to read the book in the winter season, it is strongly urged upon teachers and students not to be satisfied with them as long as the plants themselves are available.

The works most frequently consulted in the preparation of the text are those of Hooker, Gray, Bentley and Oliver.

Finally, the Authors look for indulgence at the hands of their fellow-teachers, and will be glad to receive suggestions tending to increase the usefulness of the work, and to extend a taste for what must ever be regarded as one of the most refining as well as one of the most practically useful of studies.

September, 1879.

cell formation

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TABLE OF THE COMMON PLANTS EXAMINED, TOGETHER WITH THE FAMILIES TO WHICH THEY BELONG.

Buttercup, Hepatica, Marsh-Marigold.	CROWFOOT FAMILY.
Shepherd's Purse	CRESS FAMILY.
Round-leaved Mallow	MALLOW FAMILY.
Garden Pea	PULSE FAMILY.
Great Willow-herb	EVENING-PRIMROSE FAMILY.
Sweet-Brier, Crab-Apple	ROSE FAMILY.
Water-Parsnip	PARSLEY FAMILY.
Dandelion	COMPOSITE FAMILY.
Catnip	MINT FAMILY.
Cucumber	GOURD FAMILY.
Willow	WILLOW FAMILY.
Dog's-tooth Violet, Trillium	LILY FAMILY.
Indian Turnip, Calla	ARUM FAMILY.
Showy Orchis	ORCHIS FAMILY.
Timothy	GRASS FAMILY.

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THE ELEMENTS

OF

STRUCTURAL BOTANY

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1. The study of Botany is commonly rendered unattractive to the beginner by the order in which the parts of the subject are presented to him. His patience becomes exhausted by the long interval which must necessarily elapse before he is in a position to do any practical work for himself. In accordance with the usual plan, some months are spent in committing to memory a mass of terms descriptive of the various modifications which the organs of plants undergo; and not until the student has mastered these, and perhaps been initiated into the mysteries of the fibro-vascular system, is he permitted to examine a plant as a whole. In this little work, we purpose, following the example of some recent writers, to reverse this order of things, and at the outset to put into the learner's hands some common plants, and to lead him, by his own examination of these, to a knowledge of their various organs—to

cultivate, in short, not merely his memory, but also, and chiefly, his powers of observation.

It is desirable that the beginner should provide himself with a magnifying glass of moderate power for examining the more minute parts of specimens; a sharp penknife for dissecting; and a couple of fine needles, which he can himself insert in convenient handles, and which will be found of great service in separating delicate parts, and in impaling fine portions for examination with the aid of the lens.

CHAPTER I.

EXAMINATION OF A BUTTERCUP.

2. To begin with, there is no plant quite so suitable as our common Buttercup. This plant, which has conspicuous yellow flowers, may be found growing in almost every moist meadow. Having found one, take up the whole plant, loosening the soil a little, so as to obtain as much of the Root as possible. Wash away the earth adhering to the latter part, and then proceed to examine your specimen. Beginning with the **Root**, (Fig. 1) the first noticeable

Fig. 1.

thing is that it is not of the same colour as the rest of

the plant. It is nearly white. Then it is not of the same *form* as the part of the plant above ground. It is made up of a number of thread-like parts which spread out in all directions, and if you examine one of these threads through your magnifying glass, you will find that from its surface are given off many finer threads, called *rootlets*. These latter are of great importance to the plant; it is largely by means of their tender extremities, and the parts adjacent to these, that it imbibes the nutritious fluids contained in the soil.

Whilst you are looking at these delicate rootlets, you may perhaps wonder that they should be able to make their way through the soil, but how they do this will be apparent to you if you examine the tip of one of them with a microscope of considerable power. Fig. 2 represents such a tip highly magnified. It is to be observed that the growth of the rootlet does not take place at the very extremity, but immediately behind it. The extreme tip consists of harder and firmer matter than that behind, and is in fact a sort of cap or thimble to protect the growing part underneath. As the rootlet grows, this little thimble is pushed on first through the crevices of the soil, and, as you may suppose, is soon worn away on the outside, but it is as rapidly renewed by the rootlet itself on the inside.

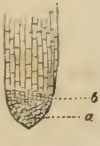

Fig. 2.

Another difference between the root and the part above ground you will scarcely have failed to discover: the root has no leaves, nor has it any buds.

You may describe the root of the Buttercup as *fibrous*.

Fig. 3

3. Let us now look at the **Stem.** (Fig.3.) It is upright, pretty firm, coloured green, and leaves spring from it at intervals. As there is scarcely any appearance of wood in it, we may describe it as *herbaceous*. At several points along the main stem branches are given off, and you will observe that immediately below the point from which every branch springs there is a leaf on the stem. The angle between the leaf and the stem, on the upper side' is called the *axil* of the leaf (*axilla*, an armpit), and it is a rule to which there are scarcely any exceptions, that branches can only spring from the axils of leaves.

The stem and all the branches of our plant terminate, at their upper extremities, either in flowers or in flower-buds.

4. Let us now consider the **Leaves.** A glance will show you that the leaves of this plant are not all alike. Those at the lower end of the stem have long stalks, (Fig. 4) which we shall henceforward speak of as *petioles.* Those a little higher up have petioles too, but they are not

quite so long as the lower ones, and the highest leaves have no petioles at all. They appear to be sitting on the stem, and hence are said to be *sessile*. The lowest leaves of all, as they seem to spring from the root, may be described as *radical*, whilst the higher ones may be called *cauline* (*caulis*, a stem). The broad part of a leaf is its *blade*. In the plant we are now examining, the blades of the leaves are almost divided into distinct pieces, which are called *lobes*, and each of these again is more or less deeply *cut*. Both petioles and blades of our leaves are covered with minute hairs, and so are said to be *hairy*.


Fig. 4.

Hold up one of the leaves to the light, and you will observe that the veins run through it in all directions, forming a sort of net-work. The leaves are therefore *net-veined*.

The points along the stem from which the leaves arise are called *nodes*, and the portions of stem between the nodes are called *internodes*.

5. Let us next examine the **Flowers**. Each flower in our plant is at the end either of the stem or of a branch of the stem. The upper portions of the stem and its branches, upon which the flowers are raised, are called the *peduncles* of the flowers.


Fig. 5.

Take now a flower which has just opened. Beginning at the outside, you will find five little spreading leaves, somewhat yellowish in colour. Each of these is called a *sepal*, and the five together form the **calyx** of the

flower. If you look at a flower which is a little older, you will probably not find any sepals. They will have fallen off, and for this reason they are said to be *deciduous.* So, in like manner, the leaves of most of our trees are deciduous, because they fall at the approach of winter. You will find that you can pull off the sepals one at a time, without disturbing those that remain. This shows that they are not connected together. They are therefore said to be *free*, and the calyx is described as *polysepalous.*

Inside the circle of sepals there is another circle of leaves, usually five in number, bright yellow in colour, and much larger than the sepals. Each of them is called a *petal*, and the five together form the **corolla** of the flower. Observe carefully that each petal is not inserted in front of a sepal, but in front of the space between two sepals. The petals can be removed one at a time like the sepals. They, too, are free, and the corolla is *polypetalous.* If you compare the petals with one another, you will see that they are, as nearly as possible, alike in size and shape. The corolla is therefore *regular.*

6. We have now examined, minutely enough for our present purpose, the calyx and corolla. Though their divisions are not coloured green, like the ordinary leaves of the plant, still, from their general form, you will have no difficulty in accepting the statement that the sepals and petals are in reality *leaves.* It will not be quite so apparent that the parts of the flower which still remain are also only modifications of the same structure. But there is good evidence that this is the case. Let us,


Fig. 6.

however, examine these parts that remain. There is first a large number of little yellow bodies, each at the top of a little thread-like stalk. Each of these bodies, with its stalk, is called a **stamen**. The little body itself is the *anther*, and the stalk is its *filament*. Your magnifying glass will show you that each anther consists of two oblong sacs, united lengthwise, the filament being a continuation of the line of union. (Fig. 7.)


Fig. 7. Fig 8

If you look at a stamen of a flower which has been open some time, you will find that each anther-cell has split open along its outer edge, and has thus allowed a fine yellowish dust to escape from it. (Fig. 8.) This dust is called *pollen*. A powerful magnifier will show this pollen to consist of grains having a distinct form.

As the stamens are many in number, and free from each other, they are said to be *polyandrous.*


Fig. 9.

7. On removing the stamens there is still left a little raised mass, (Fig. 9) which with the aid of your needle you will be able to separate into a number of distinct pieces, all exactly alike, and looking something like unripe seeds. Fig. 10 shows one of them very much magnified, and cut through lengthwise. These little bodies, taken separately, are called *carpels*. Taken together, they form the **pistil**. They are hollow, and each of them contains, as the figure shows, a little grain-like substance attached to the lower end of its cavity. This substance, in its present condition, is the *ovule*, and later on becomes the *seed*.


Fig 10.

You will notice that the carpel ends, at the top, in a little bent point, and that the convex edge is more or less rough and moist, so that in flowers whose anthers have burst open, a quantity of pollen will be found sticking there. This rough upper part of the carpel is called the *stigma*. Fig. 11 shows a stigma greatly magnified. In many plants the stigma is raised on a stalk above the ovary. Such a stalk is called a *style*. In the Buttercup the style is so short as to be almost suppressed. When the style is entirely absent the stigma is said to be sessile. The hollow part of the carpel is the *ovary*.

Fig. 11.

In our plant the pistil is not connected in any way with the calyx, and is consequently said to be *free* or *superior*, and, as the carpels are not united together, the pistil is said to be *apocarpous*.

8. Remove now all the carpels, and there remains nothing but the swollen top of the peduncle. This swollen top is the *receptacle* of the flower. To it, in the case of the Buttercup, all four parts, calyx, corolla, stamens, and pistil, are attached. When a flower has all four of these parts it is said to be *complete*.

9. Let us now return to our statement that the structure of stamens and pistils is only a modification of leaf-structure generally. The stamen looks less like a leaf than any other part of the flower. Fig. 12 will, however, serve to show you the plan upon which the botanist considers a stamen to be formed. The anther corresponds to the leaf-blade, and the filament to the petiole. The two cells of the anther correspond to the two

Fig. 12

halves of the leaf, and the cells burst open along what answers to the margin of the leaf.

10. In the case of apocarpous pistils, as that of the Buttercup, the botanist considers each carpel to be formed by a leaf-blade doubled lengthwise until the edges meet and unite, thus forming the ovary. Fig. 13 will make this clear.

11. There are many facts which support this theory as to the nature of the different parts of the flower. Suffice it to mention here, that in the white Water-Lily, in which there are several circles of sepals and petals, it is difficult to say where the sepals end and the petals begin, on account of the gradual change from one set to the other. And not only is there a gradual transition from sepals to petals, but there is likewise a similar transition from petals to stamens, some parts occurring, which are neither altogether petals, nor altogether stamens, but a mixture of both, being imperfect petals with imperfect anthers at their summits. We can thus trace ordinary leaf-forms, by gradual changes, to stamens.

Fig. 13.

We shall, then, distinguish the leaves of plants as *foliage-leaves*, and *flower-leaves*, giving the latter name exclusively to the parts which make up the flower, and the former to the ordinary leaves which grow upon the stem and its branches.

12. You are now to try and procure a Buttercup whose flowers, or some of them, have withered away, leaving only the head of carpels on the receptacle. The carpels will have swollen considerably, and will now show themselves much more distinctly than in the


Fig. 14.


Fig. 15.

flower which we have been examining. This is owing to the growth of the ovules, which have now become seeds. Remove one of the carpels, and carefully cut it through the middle lengthwise. You will find that the seed almost entirely fills the cavity. (Figs. 14 and 15.)


Fig. 16.

This seed consists mainly of a hard substance called *albumen*, enclosed in a thin covering. At the lower end of the albumen is situated a very small body, which is the *embryo*. It is this which develops into a new plant when the seed germinates.

13. We have seen then that our plant consists of several parts:

(1). **The Root.** This penetrates the soil, avoiding the light. It is nearly white, is made up of fibres, from which numbers of much finer fibres are given off, and is entirely destitute of buds and leaves.

(2). **The Stem.** This grows upward, is coloured, bears foliage-leaves at intervals, gives off branches from the axils of these, and bears flowers at its upper end.

(3). **The Leaves.** These are of two sorts: *Foliage-leaves* and *Flower-leaves.* The former are sub-divided into *radical* and *cauline*, and the latter make up the flower, the parts of which are four in number, viz.: **calyx corolla, stamens, and pistil.**

It is of great importance that you should make yourselves thoroughly familiar with the different parts of the plant, as just described, before going further, and to that end it will be desirable for you to review the present chapter carefully, giving special attention to those

parts which were not perfectly plain to you on your first reading.

In the next chapter, we shall give a very brief account of the *uses* of the different parts of the flower. If found too difficult, the study of it may be deferred until further progress has been made in plant examination.

CHAPTER II.

FUNCTIONS OF THE ORGANS OF THE FLOWER.

14. The chief use of the calyx and corolla, or *floral envelopes*, as they are collectively called, is *to protect the other parts of the flower*. They enclose the stamens and pistil in the bud, and they usually wither away and disappear shortly after the anthers have shed their pollen, that is, as we shall presently see, as soon as their services as protectors are no longer required.

15. The corollas of flowers are usually bright-coloured, and frequently sweet-scented. There is little doubt that these qualities serve to attract insects, which, in search of honey, visit blossom after blossom, and, bringing their hairy limbs and bodies into contact with the open cells of the anthers, detach and carry away quantities of pollen, some of which is sure to be rubbed off upon the stigmas of other flowers of the same kind, subsequently visited.

16. The essential part of the stamen is the anther, and the purpose of this organ is to produce the pollen, which, as you have already learned, consists of minute *grains*, having a definite structure. These little grains are usually alike in plants of the same kind. They are

furnished with two coats, the inner one extremely thin, and the outer one much thicker by comparison. The interior of the pollen-grain is filled with liquid matter. When a pollen-grain falls upon the moist stigma it *begins to grow* in a curious manner. (Fig. 17). The inner coat pushes its way through the outer one, at some weak point in the latter, thus forming the beginning of a slender tube. This slowly penetrates the stigma, and then extends itself downwards through the style, until it comes to the cavity of the ovary. The liquid contents of the pollen-grain are carried down through this tube, which remains closed at its lower end, and the body of the grain on the stigma withers away.


Fig. 17.

The ovary contains an ovule, which is attached by one end to the wall of the ovary. The ovule consists of a kernel, called the *nucleus*, which is usually surrounded by two coats, through both of which there is a minute opening to the nucleus. This opening is called the *micropyle*, and is always to be found at that end of the ovule which is not attached to the ovary. (Fig. 18, *m*.)


Fig. 18.

About the time the anthers discharge their pollen, a little cavity, called the *embryo-sac*, appears inside the nucleus, near the micropyle. The pollen-tube, with its liquid contents, enters the ovary, passes through the micropyle, penetrates the nucleus, and attaches itself to the outer surface of the embryo-sac. Presently the tube becomes empty, and then withers away, and, in the meanwhile, a minute body, which in time developes into the embryo, makes its appearance in the embryo-sac, and from that time the ovule may properly be called a seed.

17. In order that ovules may become seeds, it is always essential that they should be *fertilized* in the manner just described. If we prevent pollen from reaching the stigma—by destroying the stamens, for instance—the ovules simply shrivel up and come to nothing.

Now it is the business of the flower to produce seed, and we have seen that the production of seed depends mainly upon the stamens and the pistil. These organs may consequently be called the *essential organs* of he flower. As the calyx and corolla do not play any *direct* part in the production of seed, but only protect the essential organs, and perhaps attract insects, we can understand how it is that they, as a rule, disappear early. Their work is done when fertilization has been accomplished.

Having noticed thus briefly the part played by each set of floral organs, we shall now proceed to the examination of two other plants, with a view to comparing their structure with that of the Buttercup.

CHAPTER III.

EXAMINATION OF HEPATICA AND MARSH-MARIGOLD—RESEMBLANCES BETWEEN THEIR FLOWERS AND THAT OF BUTTERCUP.

18. **Hepatica.** You may procure specimens of the Hepatica almost anywhere in rich dry woods, but you will not find it in flower except in spring and early summer. It is very desirable that you should have the plant itself, but for those who are unable to obtain

specimens, the annexed engravings may serve as a substitute.

Beginning then at the root of our new plant, you see that it does not differ in any great measure from that of the Buttercup. It may in like manner be described as *fibrous*.

Fig. 10.

The next point is the stem. You will remember that in the Buttercup the stem is that part of the plant from which the leaves spring. Examining our Hepatica in the light of this fact, and following the petioles of the leaves down to their insertion, we find that they and the roots appear to spring from the same place—that there is, apparently, *no stem*. Plants of this kind are therefore called *acaulescent*, that is, *stemless*, but it must be carefully borne in mind that the absence of the

stem is only apparent. In reality there is a stem, but it is so short as to be almost indistinguishable.

The leaves of the Hepatica are of course all *radical.* They will also be found to be *net-veined.*

19. The **Flowers** of the Hepatica are all upon long peduncles, which, like the leaves, appear to spring from the root. Naked peduncles of this kind, rising from the ground or near it, are called *scapes.* The flower-stalks of the Tulip and the Dandelion furnish other familiar examples.

Let us now proceed to examine the flower itself. Just beneath the coloured leaves there are three leaflets, which you will be almost certain to regard, at first sight, as sepals, forming a calyx. It will not be difficult, however, to convince you that this conclusion would be incorrect. If, with the aid of your needle, you turn back these leaflets, you will readily discover, between them and the coloured portion of the flower, *a very short bit of stem* (Fig. 20), the upper end of which is the *receptacle.* As these leaflets, then, are on the peduncle, *below* the receptacle, they cannot be sepals.


Fig. 20.

They are simply small foliage leaves, to which, as they are found beside the flower, the name *bracts* is given. Our flower, then, is apparently without a calyx, and in this respect is different from the Buttercup. The whole four parts of the flower not being present, it is said to be *incomplete.*

20. It may be explained here that there is an understanding among botanists, that if the calyx and corolla are not both present it is always the corolla which is wanting, and so it happens that the coloured part of the flower under consideration, though resembling a

corolla, must be regarded as a calyx, and the flower itself, therefore, as *apetalous.*

21. Remove now these coloured sepals, and what is left of the flower very much resembles what was left of our Buttercup, after the removal of the calyx and corolla. The stamens are very numerous, and are inserted on the receptacle. The carpels are also numerous, (Fig. 21) are inserted on the receptacle, and are free from each other (*apocarpous*). And if you examine one of the carpels (Fig. 22) you will find that it contains a single ovule. The flower, in short, so much resembles that of the Buttercup that you will be prepared to learn that the two belong to the same Order or Family of plants, and you will do well to observe and remember such resemblances as have just been brought to your notice, when you set out to examine plants for yourselves, because it is only in this way, and by slow steps, that you can acquire a satisfactory knowledge of the reasons which lie at the foundation of the classification of plants.

Fig. 21.

Fig. 22.

22. **Marsh-Marigold.** This plant grows in wet places almost everywhere, and is in flower in early summer.

Note the entire aosence of nairs on the surface of tne plant. It is therefore *glabrous.*

The root, like that of the Buttercup anu of the Hepatica, is *fibrous.*

The stem is hollow and furrowed.

The foliage-leaves are of two kinds, as in the Buttercup. The radical leaves spring from the base of the stem, whilst the higher ones are cauline. The leaves

are not lobed, as in the other two plants, but are indented on the edge. They are also net-veined.

Fig. 23.

23. Coming to the flower (Fig. 23) we find a circle, or whorl, of bright yellow leaves, looking a good deal like the petals of the Buttercup, but you will look in vain for the corresponding sepals. In this case there is no whorl of bracts to mislead you. Are we to say, then, that there is no calyx? If we adhere to the understanding mentioned when describing the Hepatica, we must suppose the *corolla* to be wanting, and then the bright yellow leaves of our plant will be the *sepals*, and will together constitute the calyx. As to the number of the sepals, you will find, as in the Hepatica, some variation. Whilst the normal number is five, some flowers will be found to have as many as nine.

24. The stamens are next to be examined, but you should first satisfy yourselves as to whether the calyx is polysepalous or otherwise, and whether it is free from the other floral leaves or not. If your examination be properly made, it will show you that the calyx is free and polysepalous.

The stamens are very much like those of the Buttercup and Hepatica. They are numerous, they have both anthers and filaments, and they shed their pollen through slits on the outer edges of the anthers. They are all separate from each other (polyandrous) and are all inserted on the receptacle. On this latter account they are said to be *hypogynous*.

25. Remove the stamens, and you have left, as before, a head of carpels (Fig. 24). Examine one: there

Fig. 24

is the lower broad part, which you recognize as the *ovary*, the very short style, and the sticky stigma. To all appearance the carpels are pretty much the same as those of the two plants already examined. It will not do, however, to trust altogether to appearances in this case. Cut open a carpel and you find that, instead of a single ovule at the bottom of the ovary, there are several ovules in a row along that edge of the ovary which is turned towards the centre of the flower.

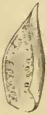

Fig. 25.

The ovary is, in fact, a *pod*, and, when the seeds ripen, splits open along its inner edge. If you can find one which has split in this way, you can hardly fail to be struck with the resemblance which it bears to a common leaf. (Fig. 25.) On the whole the resemblance between the structure of the Marsh-marigold and that of the Hepatica and Buttercup is sufficiently great to justify us in placing it in the same family with them.

26. Having now made yourselves familiar with the different parts of these three plants, you are to write out a tabular description of them according to the following form; and, in like manner, whenever you examine a new plant, do not consider your work done until you have written out such a description of it.

In the form the term *cohesion* relates to the union of *like* parts; for example, of sepals with sepals, or petals with petals; while the term *adhesion* relates to the union of *unlike* parts; for example, of stamens with corolla, or ovary with calyx. Neither cohesion nor adhesion takes place in any of the three flowers we have

examined, and accordingly, under these headings in our schedule we write down the terms polysepalous, polypetalous, &c., to indicate this fact.

The symbol ∞ means "indefinite," or "numerous," and may be used when the parts of any organ exceed ten in number.

Crowfoot Family

BUTTERCUP.

ORGAN OR PART OF FLOWER.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx.		Polysepalous.	Inferior.	
Sepals.	5			
Corolla.		Polypetalous. Regular.	Hypogynous.	
Petals.	5			
Stamens.	∞	Polyandrous.	Hypogynous.	
Filaments.				
Anthers.				
Pistil.		Apocarpous.		
Carpels.	∞			
Ovary.			Superior.	

Crowfoot family

HEPATICA.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx. *Sepals.*	7–12	Polysepalous.	Inferior.	Coloured like a Corolla.
~~Calyx.~~ Corolla *Petals.*				Wanting.
Stamens. *Filaments.* *Anthers.*	∝	Polyandrous.	Hypogynous.	
Pistil. *Carpels.* *Ovary.*	∝	Apocarpous.	Superior.	

6 Crowfoot F.

MARSH-MARIGOLD.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS
Calyx. *Sepals.*	5–9	Polysepalous.	Inferior.	Coloured like a Corolla.
Corolla. *Petals.*				Wanting.
Stamens. *Filaments.* *Anthers.*	∝	Polyandrous.	Hypogynous.	
Pistil. *Carpels.* *Ovary.*	∝	Apocarpous	Superior.	Carpels contain several seeds.

CHAPTER IV.

EXAMINATION OF OTHER COMMON PLANTS WITH HYPOGYNOUS STAMENS. SHEPHERD'S PURSE. ROUND-LEAVED MALLOW.

27. We shall now proceed to examine some plants. the flowers of which exhibit, in their structure, important variations from the Buttercup, Hepatica, and Marsh-Marigold.

Cress Family

Shepherd's Purse. This plant, (Fig. 26). is one of the commonest of weeds. As in the Buttercup, the foliage-leaves are of two kinds, radical and cauline, the former being in a cluster around the base of the stem. The cauline leaves are all sessile, and each of them, at its base, projects backward on each side of the stem, so that the leaf somewhat resembles the head of an arrow. Such leaves are, in fact, said to be *sagittate*, or arrow-shaped. The flowers grow in a cluster at the top of the stem, and, as the season advances, the peduncle gradually elongates, until, at the close of the summer, it forms perhaps half of the entire length of the stem. You will observe, in this plant, that each separate flower is raised on a little stalk of its own. Each of these little stalks is a *pedicel*, and when pedicels are present, the term peduncle is applied to the portion of stem which supports the whole cluster.

Fig. 27.

Fig. 28.

28. The flowers, (Fig. 27), are rather small, and so will require more than ordinary care in their examination. The calyx is polysepalous, and of four sepals. The corolla is polypetalous, and of four petals. The stamens, (Fig. 28), are six in number, and if you examine them attentively, you will see that two of them are shorter than the other four. The stamens are consequently said to be *tetradynamous*. But if there had been only *four* stamens, in two sets of two each, they would have been called *didynamous*. The stamens are inserted on the receptacle (hypogynous). The pistil is separate from the other parts of the flower (superior).

29. To examine the ovary, it will be better to select a ripening pistil from the lower part of the peduncle.

It is a flat body, shaped something like a heart, (Fig 29) and having the short style in the notch. A ridge divides it lengthwise on each side. Carefully cut or pull away the lobes, and this ridge will remain, presenting now the appearance of a narrow loop, with a very thin membranous partition stretched across it. Around the edge, on both sides of the partition, seeds are suspended from slender stalks. (Fig. 30). There are, then, *two carpels united together*, and the pistil is, therefore, *syncarpous*.

Fig. 29.

Fig. 30

The peculiar pistil of this flower should be carefully noticed, as it is the leading character of a whole group of plants. When you meet with such a pistil, you may be pretty certain that the plant to which it belongs is a member of the *Cress* or *Crucifer* family, so called from the four petals sometimes spreading out like the arms of a cross. We shall find, however, that there are cross-shaped corollas belonging to plants of other groups.

SHEPHERD'S PURSE.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx. *Sepals.*	4	Polysepalous.	Inferior.	
Corolla. *Petals.*	4	Polypetalous.	Hypogynous.	
Stamens. *Filaments.* *Anthers.*	6	Tetradynamous.	Hypogynous.	
Pistil. *Carpels* *Ovary.*	2	Syncarpous.	Superior.	The two cells of the ovary separated by a thin partition.

30. Mallow. The round-leaved Mallow (Fig. 31) grows along every way side, and is a very common weed in cultivated grounds. Procure, if possible, a plant which has ripened its seeds, as well as one in flower. The root of this plant is of a different kind from those of the three plants first examined. It consists of a stout tapering part, descending deep into the soil, from the surface of which fibres are given off irregularly. A stout root of this kind is called a *tap-root*. The Carrot is another example.

Mallow 91
Malvaceae

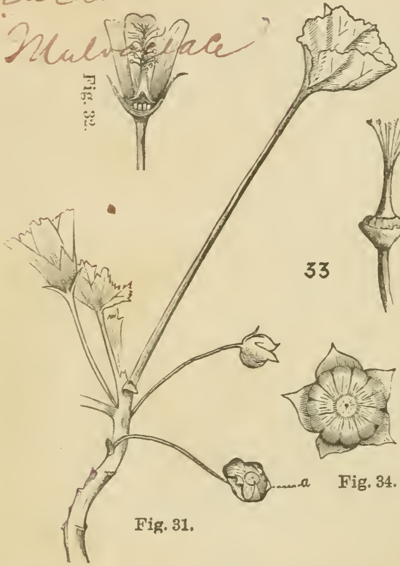

Fig. 32.

33

Fig. 34.

Fig. 31.

31. The leaves are long-petioled, net-veined and indented on the edges. On each side of the petiole, at its junction with the stem, you will observe a little leaf-like attachment, to which the name *stipule* is given. The presence or absence of stipules is a point of some importance in plant-structure, and you will do well to notice it in your examinations. You have now made yourselves acquainted with all the parts that any leaf has, viz., *blade, petiole* and *stipules*.

32. Coming to the flower, observe first that the parts of the calyx are not entirely separate, as in the flowers you have already examined. For about half their length they are united together so as to form a cup. The upper half of each sepal, however, is perfectly distinct, and forms a *tooth* of the calyx; and the fact that there are five of these teeth shows us unmistakably that the calyx is made up of five sepals. We therefore speak of it as a *gamosepalous* calyx, to indicate that the parts of it are coherent.

As the calyx does not fall away when the other parts of the flower disappear, it is said to be *persistent*. Fig. 31, *a*, shows a persistent calyx.

33. At the base of the calyx there are three minute leaf-like teeth, looking almost like an outer calyx. A circle of bracts of this kind is called an *involucre*. The three bracts under the flower of the Hepatica also constitute an involucre. As the bracts in the Mallow grow on the calyx, some botanists speak of them as an *epicalyx*.

The corolla consists of five petals, separate from each other, but united with the stamens at their base.

34. The stamens are numerous, and as their filaments are united to form a tube they are said to be *monadelphous*. This tube *springs from the receptacle*, and the stamens are therefore *hypogynous*. Fig. 32 will help you to an understanding of the relation between the petals and stamens.

Having removed the petals, split the tube of the stamens with the point of your needle. A little care will then enable you to remove the stamens without injuring the pistil. The latter organ will then be found to consist of a ring of coherent carpels, a rather stout

style, and numerous long stigmas. (Fig. 33.) If you take the trouble to count the carpels and the stigmas, you will find the numbers to correspond. As the seeds ripen the carpels separate from each other. (Fig. 34.)

MALLOW.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx.		Gamosepsalous.	Inferior.	Three bracts growing on the Calyx.
Sepals.	5			
Corolla.		Polypetalous.	Hypogynous.	
Petals.	5			
Stamens.	∞	Monadelphous	Hypogynous.	
Filaments.		United in a ring.		
Anthers.		One-celled.		
Pistil.		Syncarpous.	Superior.	
Carpels.	∞			Carpels as many
Ovary.				as the stigmas.

CHAPTER V.

EXAMINATION OF COMMON PLANTS WITH PERIGYNOUS STAMENS —GARDEN PEA. GREAT WILLOW-HERB, SWEET-BRIER, CRAB-APPLE.

Leguminoseae Rubo Family

35. **Garden Pea.** In the flower of this plant, the calyx is constructed on the same plan as in the Mallow. There are five sepals, coherent below, and spreading out into distinct teeth above (Fig. 35). The calyx is therefore gamosepalous.

Examine next the form of the corolla (Fig. 36). One difference between this corolla and those of the previous plants will strike you at once. In the flowers

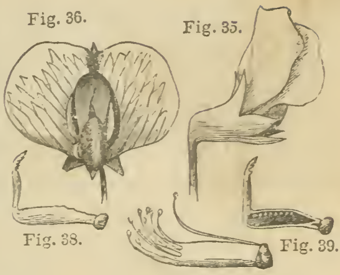

Fig. 36. Fig. 35. Fig. 38. Fig. 39. Fig. 37.

of the latter you will remember that each petal was precisely like its fellows in size and shape, and we therefore spoke of the corolla as *regular*. In the Pea, on the other hand, one of the petals is large, broad, and open, whilst two smaller ones, in the front of the flower, are united into a kind of hood. We shall speak of this corolla, then, and all others in which the petals are unlike each other in size or shape, as *irregular*.

As the Pea blossom bears some resemblance to a butterfly, it is said to be *papilionaceous*.

36. Remove now the calyx-teeth and the petals, being very careful not to injure the stamens and the pistil, enveloped by those two which form the hood. Count the stamens, and notice their form (Fig. 37). You will find ten, one by itself, and the other nine with the lower halves of their filaments joined together, or coherent. When stamens occur in this way, in two distinct groups, they are said to be *diadelphous*; if in three groups, they would be *triadelphous*; if in several groups, *polyadelphous*. In the Mallow, you will remember, they are united into *one* group, and therefore we described them as *monadelphous*.

You will perhaps be a little puzzled in trying to determine to what part of the flower the stamens are attached. If you look closely, however, you will see that the attachment, or *insertion*, is not quite the same as in the Buttercup and the other flowers examined.

In the present instance, they are inserted upon the lower part of the calyx, and so they are described as *perigynous*, a term meaning "around the pistil."

37. But the pistil (Figs. 38, 39) is not attached to the calyx. It is *free*, or *superior*. If you cut the ovary across, you will observe there is but one cell, and if you examine the stigma, you will find that it shows no sign of division. You may therefore be certain that the pistil is a single carpel.

You are now prepared to fill up the schedule descriptive of this flower.

GARDEN PEA.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx. *Sepals.*	5	Gamosepalous.	Inferior.	
Corolla. *Petals.*	5	Polypetalous. Irregular.	Hypogynous.	
Stamens. *Filaments.* *Anthers.*	10	Diadelphous.	Perigynous.	
Pistil. *Carpels.* *Ovary.*	1	Apocarpous.	Superior.	

38. The beginner will be very likely to think, from its appearance, that the largest of the petals is made up of two coherent ones, but the following considerations show clearly that this is not the case. In the Buttercup, and other flowers in which the number of sepals and petals is the same, the petals do not stand

before the sepals, but before the spaces between them. In the Pea-blossom this rule holds good if the large petal is considered as one, but not otherwise. Again, the veining of this petal is similar to that of a common leaf, there being a central rib from which the veins spring on each side; and lastly, there are some flowers of the Pea kind—Cassia, for example—in which this particular petal is of nearly the same size and shape as the other four. Evening Primrose Family

39. **Great Willow-herb.** This plant is extremely common in low grounds and newly cleared land, and you may easily recognize it by its tall stem and bright purple flowers.

Observe the position of the flowers. In the three plants first examined we found the flowers at the end of the stem. In the Willow-herb, as in the Mallow, they spring from the sides of the stem, and immediately below the point from which each flower springs you will find a small leaf or bract (Fig. 40.) Flowers which arise from the axils of bracts are said to be *axillary*, whilst those which are at the ends of stems are called *terminal*, and you may remember that flowers can only be produced in the axils of leaves and at the ends of stems and branches.

Fig. 40.

40. Coming to the flower itself, direct your attention, first of all, to the position of the ovary. You will find it apparently under the flower, in the form of a tube tinged with purple. It is not in reality under the flower, because its purplish covering is the calyx, or

more accurately the *calyx-tube*, which adheres to the whole surface of the ovary, and expands above into four long teeth. The ovary therefore is *inferior*, and the calyx of course *superior*, in this flower. As the sepals unite below to form the tube the calyx is gamosepalous.

The corolla consists of four petals, free from each other, and is consequently polypetalous. It is also regular, the petals being alike in size and shape. Each petal is narrowed at the base into what is called the *claw* of the petal, the broad part, as in the ordinary foliage-leaf, being the *blade*.

The stamens are eight in number (octandrous), four short and four long, and are attached to the calyx (perigynous).

41. The pistil has its three parts, ovary, style, and stigma, very distinctly marked. The stigma consists of four long lobes, which curl outwards after the flower opens. The style is long and slender. The examination of the ovary requires much care. You will get the best idea of its structure by taking one which has just burst open, and begun to discharge its seeds (Fig. 41). The outside will then be seen to consist of four pieces *(valves)*, whilst the centre is occupied by a slender four-winged column, (Fig. 42), in the grooves of which the seeds are compactly arranged. The pistil thus consists

Fig. 42.

Fig. 41.

of four carpels united together, and is therefore *syncarpous*. Every seed is furnished with a tuft of silky hairs, which greatly facilitates its transportation by the wind.

42. The Willow-herb furnishes an excellent example of what is called *symmetry*. We have seen that the calyx and corolla are each made up of four parts; the stamens are in two sets of four each; the stigma is four-lobed, and the ovary has four seed-cells. A flower is *symmetrical* when each set of floral leaves contains either the same number of parts or a *multiple* of the same number.

Observe that the leaves of our plant are net-veined.

The schedule will be filled up as follows:

GREAT WILLOW-HERB.

ORGAN	NO.	COHESION.	ADHESION.	REMARKS.
Calyx.		Gamosepalous.	Superior.	
Sepals.	4			
Corolla.		Polypetalous.	Perigynous.	
Petals.	4			
Stamens.	8	Octandrous.	Perigynous.	Four short and four long.
Filaments.				
Anthers.				
Pistil.		Syncarpous.	Inferior.	
Carpels.	4			Seeds provided with tufts of hair
Ovary.				

43. Sweet Brier. As in the flower just examined, the

Fig. 43.

sepals of Sweet-Brier are not entirely distinct; their lower halves cohere to form a tube, and the calyx is therefore gamosepalous.

The corolla consists of five separate petals of the same size and shape, and is therefore both regular and polypetalous.

The stamens are very numerous, and separate from each other. As in the Pea and the Willow-herb, so in this flower they will be found to be attached to the calyx. They are, therefore, *perigynous*.

44. To understand the construction of the pistil, you must make a vertical section through the roundish green mass which you will find on the under side of the flower. You will then have presented to you some such appearance as that in Fig. 44. The green mass, you will observe, is hollow. Its outer covering is simply the continuation of the calyx-tube. *The lining of this calyx-tube is the receptacle of the flower*; to it are attached the separate carpels which together

Fig. 44.

constitute the pistil (Fig. 45), just as the carpels of the Buttercup are attached to the *raised* receptacle of that flower.

Fig 45.

We must remind you again that whenever the ovary is enclosed in the calyx-tube, and the calyx appears to spring from the summit of the ovary, the latter is said to be *inferior*, and the former *superior*.

Rose Family

SWEET-BRIER.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx. *Sepals.*	5	Gamosepalous	Superior.	
Corolla *Petals.*	5	Polypetalous.	Perigynous.	
Stamens.	∞	Polyandrous.	Perigynous.	
Pistil. *Carpels.*	∞	Apocarpous.	Inferior.	The hollow receptacle lines the calyx-tube

45. Crab-Apple. The flower of the Crab-Apple (Fig. 46), is in most respects, like that of Sweet-Brier. The calyx is gamosepalous, its parts being united below into a tube. The corolla is of five separ-

Fig 46.

Fig. 47.

ate petals. The stamens are numerous and are inserted on the calyx.

The structure of the pistil (Figs. 47, 48), however, is somewhat different. On making a cross-section through the young apple, five cells containing the unripe seeds are seen radiating from the centre. These seed-vessels are imbedded in a fleshy mass, the outer limit of which is marked by a circle of green dots, and outside these dots is the flesh which constitutes the eatable part of

Fig. 48.

the apple. The inner mass, which encloses the core, belongs to the receptacle, whilst the outer edible portion is the enlarged calyx. At the end opposite the stem will be found the persistent calyx-teeth. We have in this flower, therefore, a *syncarpous* pistil of five carpels, instead of an apocarpous one, as in Sweet-Brier.

Rose Farnle

CRAB-APPLE.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx.		Gamosepalous	Superior.	
Sepals.	5			
Corolla.		Polypetalous.	Perigynous.	
Petals.	5			
Stamens.	∞	Polyandrous.	Perigynous.	
Pistil.		Syncarpous.	Inferior.	Fruit consists chiefly of a fleshy enlargement of the Calyx-tube.
Carpels.	5			

CHAPTER VI.

EXAMINATION OF A PLANT WITH EPIGYNOUS STAMENS—WATER PARSNIP.

Fig. 51.

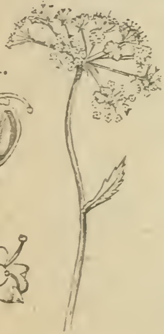

Fig. 50. Fig. 49.

46. Water-Parsnip. This is a common swamp plant in Canada; but if any difficulty be experienced in procuring specimens the flower of the common Carrot or Parsnip may be substituted for it, all these plants being closely related, and differing but slightly in the structure of their flowers.

Notice first the peculiar appearance of the flower cluster. (Fig. 49.) There are several pedicels, nearly of the same length, radiating from the end of the peduncle, and from the end of each pedicel radiate in like manner a number of smaller ones, each with a flower at its extremity. Such a cluster is known as an *umbel*. If, as in the present case, there are groups of secondary pedicels, the umbel is *compound*. As the flowers are very small we shall be obliged to use the lens all through the examination. Even with its aid you will have a little difficulty in making out the calyx, the tube of which, in this flower, adheres to the surface of the ovary, as in Willow-herb, and is reduced above to a mere rim or border, of five minute teeth. The petals are five in number, and free from each other. Observe that each of them is *incurved* at its extremity. (Fig. 50.) They are inserted *on a disk which crowns the*

ovary, as are also the five stamens, which are hence said to be *epigynous*. In the centre of the flower are two short styles projecting above the disk, and a vertical section through the ovary (Fig. 51) shows it to be two-celled, with a single seed suspended from the top of each cell.

Parsley family

WATER-PARSNIP.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx. *Sepals.*	5	Gamosepalous.	Superior.	Calyx-teeth almost obsolete.
Corolla. *Petals*	5	Polypetalous.	Epigynous	Petals incurved.
Stamens.	5	Pentandrous.	Epigynous.	
Pistil. *Carpels.*	2	Syncarpous.	Inferior.	

CHAPTER VII.

EXAMINATION OF COMMON PLANTS WITH EPIPETALOUS STAMENS —DANDELION CATNIP.

47. **Dandelion.** The examination of this flower will be somewhat more difficult than that of any we have yet undertaken.

Provide yourselves with specimens in flower and in seed.

The root of the plant, like that of the Mallow, is a tap-root.

The stem is almost suppressed, and, as in the case of the Hepatica, the leaves are all radical. They are also net-veined.

The flowers are raised on scapes, which are hollow. At first sight the flower appears to have a calyx of many sepals, and a corolla of many petals. Both of these appearances, however, are contrary to facts. With a sharp knife cut the flower through the middle from top to bottom. (Fig. 52.) It will then appear that the flower or rather *flower-head*, is made up of a large number of distinct pieces. With the point of your needle detach one of these pieces. At the lower end of it you have a small body resembling an unripe seed. (Fig. 53.) It is, in fact, an ovary. Just above this there is a short bit of stalk, surmounted by a circle of silky hairs, and above this a yellow tube with one side greatly prolonged. This yellow tube is a corolla, and a close examination of the extremity of its long side will show the existence of five minute points, or teeth, from which we infer that the tube is made up of five coherent petals. As the corolla is on the ovary it is said to be *Epigynous*.


Fig. 52.


Fig. 53.

Out of the corolla protrudes the long style, divided at its summit into two stigmas.

To discern the stamens will require the greatest nicety of observation. Fig. 54 will help you in your task. The stamens are five in number. They are inserted on the tube of the corolla (epipetalous) and their anthers cohere (Fig. 55) and form a ring about the style. When the anthers are united in this way, the stamens are said to be *syngenesio*


Fig. 54.

Fig. 55.

48. It appears, then, that the Dandelion, instead of being a single flower, is in reality a compound of a great many flowers upon a common receptacle, and what seemed at first to be a calyx is, in reality, an *involucre*, made up of many bracts.

But have the single flowers, or *florets*, as they are properly called, no calyx? The theory is that they have one, but that it is adherent to the surface of the ovary, and that the tuft of silky hairs which we noticed is a prolongation of it.

Now turn to your specimen having the seeds ready to blow away. The seeds are all single; the little bit of stalk at the top has grown into a long slender thread, and the tuft of hairs has spread out like the rays of an umbrella (Fig. 56). But though the seeds are invariably single, it is inferred from the two-lobed stigma that there are *two carpels*.

Fig. 56.

49. Flowers constructed on the plan of the Dandelion are called *composite* flowers. A very large number of our common plants have flowers of this kind. The May-weed, which abounds in waste places everywhere, the Thistle, and the Ox-Eye Daisy are examples. Composite Family

DANDELION.

Organ.	No.	Cohesion.	Adhesion.	Remarks.
Calyx. *Sepals.*	5	Gamosepalous.	Superior.	The number of sepals is *inferred from analogy* to be five.
Corolla. *Petals.*	5	Gamopetalous.	Epigynous.	
Stamens.	5	Syngenesious.	Epipetalous.	
Pistil. *Carpels.*	2	Syncarpous.	Inferior.	Number of carpels inferred from number of stigmas.

50. **Catnip.** Note carefully the appearance of the stem. It is *square.*

The flowers are in axillary clusters. The calyx is a tube (Fig. 57) terminating in five sharp teeth, and you may observe that the tube is a little longer on the upper side (that is, the side *towards* the stem) than on the lower. The corolla is somewhat peculiar. It has somewhat the appearance of a wide open mouth, and is known as a *labiate* or two-lipped corolla. The upper lip is erect, and notched at the apex. The lower lip spreads outward, and consists of a large central lobe and two small lateral ones. Altogether, therefore, there are *five* lobes constituting the gamopetalous corolla. Pull out the corolla, and with the point of your needle split its tube in front. On laying it open, the stamens will be found to be inserted upon it (epipetalous). They are four in number, two of them shorter than the other two. Hence they are described as *didynamous.* The anthers are peculiar in not having their lobes parallel (Fig. 58), these being wide apart at the base, in consequence of the expansion of the *connective,* the name given to that part of the anther which unites its two lobes or cells.

Fig. 57.

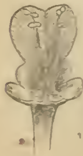

Fig. 58.

The pistil consists of a two-lobed stigma, a long style, and an ovary which seems at first as if made up of four distinct carpels (Fig. 59). But the single style and the two-lobed stigma will warn you against this supposition. The ovary really consists of *two* carpels, each of two deep lobes, and, as the seeds ripen, these lobes form four little nutlets (Fig. 60), each containing a single seed.

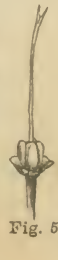

Fig. 59.


Fig. 60.

51. The group of plants to which Catnip belongs is easily distinguished by the square stem, irregular corolla, and four stamens.

CATNIP. Plant Family

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx.		Gamosepalous.	Inferior.	
Sepals.	5			
Corolla.		Gamopetalous	Hypogynous.	Two-lipped. Upper lip of two, and lower of three lobes
Petals.	5			
Stamens.	4	Didynamous.	Epipetalous	Lobes of anthers not parallel.
Anthers.				
Pistil.		Syncarpous.	Superior.	
Carpels.	2			

CHAPTER VIII.

EXAMINATION OF PLANTS WITH MONŒCIOUS AND DIŒCIOUS FLOWERS—CUCUMBER, WILLOW.

52. **Cucumber.** You can hardly have failed to notice that only a small proportion of the blossoms on a Cucumber vine produce cucumbers. A great many wither away and are apparently of no use. An attentive inspection will show that some of the blossoms

have oblong fleshy protuberances beneath them, whilst others are destitute of these attachments. Select a flower of each kind, and examine first the one with the protuberance (Fig. 61), which latter, from its appearance, you will probably have rightly guessed to be the ovary. The situation of the ovary here, indeed, is the same as in the Willow-herb. The calyx-tube adheres to its surface, and is prolonged to some little distance above it, expanding finally into five teeth. The corolla is gamopetalous, and is adherent to the calyx. Remove now the calyx and the adherent corolla, and there is left in the centre of the flower a short column, terminating in three stigmas, each two-lobed.

Fig. 61.

There are no stamens.

53. Now examine the other blossom (Fig. 62). Calyx and corolla have almost exactly the same appearance as before. Remove them, and you have left three stamens growing on the calyx-tube, and slightly united by their anthers (syngenesious).

Fig. 62.

There is no pistil.

You see now why some blossoms produce cucumbers, and others do not. Most of the blossoms have no pistil, and are termed *staminate* or *sterile* flowers, whilst the others are *pistillate* or *fertile*. Flowers in which

either stamens or pistils are wanting are also called *imperfect.* When staminate and pistillate flowers grow on the same plant, as they do in the case of the Cucumber, they are said to be *monœcious.*

54. In plants of this kind the pollen of one kind of blossom is conveyed to the stigmas of the other kind, chiefly by insects, which visit the flowers indiscriminately, in search of honey. The pollen dust clings to their hairy legs and bodies, and is presently rubbed off upon the stigma of some fertile flower.

55. In order to describe monœcious flowers, our schedule will require a slight modification. As given below, the symbol † stands for "staminate flower," and the symbol ‡ for "pistillate flower."

CUCUMBER.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Calyx.		Gamosepalous	Superior.	
Sepals.	5			
Corolla.		Gamopetalous	Perigynous.	
Petals.	5			
† Stamens.	3	Syngenesious.	Perigynous	Two anthers are 2—celled, and one 1—celled.
† Pistil.	0			
Carpels.				
‡ Stamens.	0			
‡ Pistil.		Syncarpous.	Inferior.	
Carpels.	3			

56. Willow. The flowers of most kinds of Willow appear in spring or early summer, before the leaves. They grow from the axils in long close clusters called *catkins* or *aments.* Collect a few of these *from the same tree or shrub.* You will find them to be exactly alike. If the first one you examine is covered with yellow stamens (Fig. 63), all the rest will likewise consist of stamens, and you will search in vain for any appearance of a pistil. If, on the other hand, one of your catkins is evidently destitute of stamens, and consists of oblong pistils (Fig. 64), then all the others will in like manner be found to be without stamens. Unlike our Cucumber plant, the staminate and pistillate flowers of the Willow are borne on *different* plants. These flowers are therefore said to be *diœcious.* As a general thing, staminate and pistillate catkins will be found upon trees not far apart. Procure one of each kind, and examine first the staminate one. You will probably find the stamens in pairs. Follow any pair of filaments down to their insertion, and observe that they spring from the axil of a minute bract (Fig. 65). These bracts are the *scales* of the catkin. There is no appearance of either calyx or corolla, and the flowers are therefore said to be *achlamydeous*, that is, without a covering. Now look at the fertile catkin. Each pistil will, like

Fig. 63.

Fig. 64.

Fig. 65

the stamens, be found to spring from the axil of a scale (Fig. 66). The stigma is two-lobed, and on carefully opening the ovary you observe that though there is but one cell, yet there are *two rows of seeds.* We therefore infer that the pistil consists of two carpels. The pistillate flowers, like the staminate, are achlamydeous. In diœcious plants, the process of fertilization is assisted by insects, and also very largely by the wind. Willow Family

Fig. 66.

HEART-LEAVED WILLOW.

ORGAN	NO.	COHESION.	ADHESION.	REMARKS.
Calyx.	0			
Corolla.	0			
† Stamens.	2	Diandrous.	0	
† Pistil.	0			
‡ Stamens.	0			
‡ Pistil.		Syncarpous.	0	
Carpels.	2			

CHAPTER IX.

CHARACTERISTICS POSSESSED IN COMMON BY ALL THE PLANTS PREVIOUSLY EXAMINED. STRUCTURE OF THE SEED IN DICOTYLEDONS.

57. Before proceeding further in our examination of plants, we shall direct your attention to some characters of those already examined, which they all possess in common. The leaves of every one of them are *net-veined*. Some leaves, at least, of each of them have distinct petioles and blades. The parts of the flowers we found, as a general thing, to be in *fives*. In one or two instances they were in *fours*, that is, four sepals, four petals, and so on.

58. Now, in addition to these resemblances there are others which do not so immediately strike the eye, but which, nevertheless, are just as constant. One of these is to be found in the structure of the embryo. Take a cucumber or pumpkin seed, and having soaked it for some time in water, remove the outer coat. The body of the seed will then readily split in two, except where the parts are joined at one end. (Figs. 67, 68, 69). The thick lobes are called *cotyledons*, or *seed-leaves*, and as there are two, the embryo is *dicotyledonous*. The pointed end, where the cotyledons are attached, and from which the root is developed, is called the *radicle*. Between the cotyledons, at the summit of the radicle, you will find a minute upward projection. This is a bud, which is known as the *plumule*. It developes into the stem.

Fig. 67. Fig. 68. Fig. 69.

59. If you treat a pea or a bean (Figs. 70, 71), in the same manner as the cucumber seed, you will find it to be

Fig. 70.

Fig. 71.

constructed on the same plan. The embryo of the bean is dicotyledonous also. But you will observe that in these cases the embryo occupies the whole of the interior of the seed. In describing the seed of the Buttercup, it was pointed out that the embryo occupies but a very small space in the seed, the bulk of the latter consisting of *albumen*. Seeds like those of the Buttercup are therefore called *albuminous* seeds, while those of the Bean and Pea are *exalbuminous*. But, notwithstanding this difference in the structure of the seed, the *embryo* of the Buttercup, when examined under a strong magnifier, is found to be dicotyledonous like the others. In short, the dicotyledonous embryo is a character common to all the plants we have examined—common, as a rule, to all plants possessing the other characters enumerated above. From the general constancy of all these characters, plants possessing them are grouped together in a vast **Class**, called Dicotyledonous plants, or, shortly, **Dicotyledons**.

60. Besides the characters just mentioned, there is still another one of great importance, which Dicotyledons possesses in common. It is *the manner of growth of the stem*. In the Willow, and all our trees and shrubs without exception, there is an outer layer of bark on the stem, and the stem increases in thickness, year by year, by forming a new layer just inside the bark and *outside the old wood*. These stems are therefore called *exogenous*, that is, *outside growers*.

Now, in all dicotyledonous plants, whether herbs, shrubs or trees, the stem thickens in this manner, so that **Dicotyledons** are also **Exogens**.

CHAPTER X.

EXAMINATION OF COMMON PLANTS CONTINUED. DOG'S-TOOTH VIOLET, TRILLIUM, INDIAN TURNIP, CALLA, ORCHIS, TIMOTHY.

61. **Dog's-tooth Violet.** This plant (Fig. 72) which flowers in Spring, may be pretty easily recognised by

Fig. 72.

its peculiar blotched leaves. It may be found in rich

moist pasture lands and low copses. The name "Violet" is somewhat unfortunate, because the plant is not in any way related to the true Violets. To obtain a complete specimen requires some trouble, owing to the fact that the root is commonly six inches or so below the surface of the ground; you must therefore insert a spade or strong trowel sufficiently deep to avoid cutting or breaking the tender stem. Having cleared away the adhering earth, you will find that the roots proceed from what appears to be the swollen end of the stem. This swollen mass is coated on the outside with thin scales. A section across the middle shows it to be more or less solid, with the stem growing up through it from its base. It is, in fact, not easy to say how much of this stem-like growth is, in reality, stem, because it merges gradually into the scape, which bears the flower, and the petioles of the leaves, which sheathe the scape. The swollen mass is called a *bulb*.

62. The leaves are two in number, gradually narrowing at the base into sheaths. If you hold one of them up to the light, you will observe that the veins do not, as in the leaves of the Dicotyledonous plants, form a network, but run only in one direction, namely, from end to end of the leaves. Such leaves are consequently called *straight-veined*.

63. In the flower there is no appearance of a green calyx. There are six yellow leaves, nearly alike, arranged in two sets, an outer and an inner, of three each. In such cases, we shall speak of the colored leaves collectively as the *perianth*. If the leaves are free from each other, we shall speak of the perianth as *polyphyllous*, but if they cohere we shall describe it as *gamo-*

phyllous. Stripping off the leaves of the perianth we find six stamens, with long upright anthers which open along their outer edges. If the anthers be pulled off, the filaments will be found to terminate in long sharp points.

Fig. 73.

The pistil (Fig. 73) has its three parts, ovary, style, and stigma, well marked. The stigma is evidently formed by the union of three into one. The ovary, when cut across, is seen to be three-celled (Fig. 74), and is therefore syncarpous.

Fig. 74.

Lily Family

DOG'S-TOOTH VIOLET.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Perianth.		Polyphyllous.	Inferior.	
Leaves.	6			
Stamens.	6	Hexandrous.	Hypogynous.	Filaments terminating in sharp points.
Pistil.		Syncarpous.	Superior.	
Carpels.	3			

64. **Trillium.** This plant (Fig. 75) may be found in flower about the same time as the one just described. The perianth of Trillium consists of six pieces in two sets, but in this case the three outer leaves are green, like a common calyx. The stamens are six in number. There are three styles, curving outwards, the whole of the inner side of each being stigmatic,

The ovary (Fig. 76) is six-angled, and on being cut across is seen to be three-celled.

65. Comparing this flower with that of Dog's-tooth Violet, we find the two to exhibit a striking resemblance in structure. But in one respect the plants are strikingly unlike: *the leaves of the Trillium are net-veined* (Fig. 77), as in the Exogens. From this circumstance we learn that we cannot altogether rely on the veining of the leaves as a *constant* characteristic of plants whose parts are not in fives.

Fig. 75.

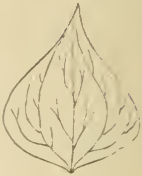

Fig 77.

Fig 76.

Lily Family

TRILLIUM.

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Perianth.		Polyphyllous.	Inferior	Sepals persistent.
Sepals.	3			
Petals.	3			
Stamens.	6	Hexandrous.	Hypogynous.	
Pistil.		Syncarpous.	Superior.	The inner face of eac style stigmatic.
Carpels.	3			
Leaves net-veined.				

66. **Indian Turnip.** This plant may be easily met with in our woods in early summer. If you are not familiar with its appearance, the annexed cut (Fig. 78)

Fig. 78.

will help you to recognise it. Procure several specimens; these will probably at first seem to you to be alike in every respect, but out of a number, some are pretty sure to differ from the rest. Notice the bulb from which the stem springs. It differs from that of the Dog's-tooth Violet, and Lilies generally, in being a solid mass. It is called a *corm*. Between the pair of

Fig. 79.

leaves you observe a curious striped sheath, having an arching, hood-like top, and enclosing an upright stalk, the top of which almost touches the hood (Fig. 79). Can this be a flower? It is certainly the only thing about the plant which at all resembles a flower, and yet how different it is from any we have hitherto examined! Carefully cut away the sheaths from all your specimens. Most, and perhaps all, of them will then present an appearance like that in Fig. 80. If none of them be like Fig. 81, it will be well to gather a few more plants. We shall suppose, however, that you have been fortunate in obtaining both kinds, and will proceed with our examination. Take first a specimen corresponding with Fig. 80. Around the base of the column are compactly arranged many spherical green bodies, each tipped with a little point. Separate one of these from the rest, and cut it across. It will be found to contain several ovules, and is, in fact, an ovary, the point at the top being a stigma. In the autumn, a great change will have taken place in the appearance of plants like the one we are now examining. The arched hood will have disappeared, as also the long naked top of the column, whilst the part below, upon which we are now engaged, will have

Fig. 80. Fig. 81

vastly increased in size, and become a compact ball of red berries. There can be no doubt, then, that we have here a structure analogous to that found in the Cucumber and the Willow, the fertile, or pistillate, flowers being clustered together separately. But in the Cucumber all the flowers were observed to be furnished with calyx and corolla, and in the Willow catkins, though floral envelopes were absent, each pair of stamens and each pistil was subtended by a bract. In the present plant there are no floral envelopes, nor does each pistil arise from a separate bract.

67. But, you will now ask, what is this sheathing hood which we find wrapped about our column of pistils? There is no doubt that we must look upon it as a *bract*, because from its base the flower-cluster springs. So that, whilst the flowers of Indian-Turnip are, like those of Willow, imperfect and diœcious, the clusters differ in having but a single bract instead of a bract under each flower.

68. We must now examine one of the other specimens; and we shall have no difficulty in determining the nature of the bodies which, in this case, cover the base of the column. They are evidently stamens, and your magnifying-glass will show you that they consist mostly of anthers, the filaments being extremely short, and that some of the anthers are two-celled, and some four-celled, all discharging their pollen through little holes at the top of the cells.

69. The column upon which, in plants like Indian-Turnip, the flowers are crowded, is known as a *spadix*, and the surrounding bract as a *spathe*.

You will observe that the leaves of this plant are *net-veined*, as we found them in the Trillium.

Arum Family

INDIAN-TURNIP.

ORGAN.	NO.	COHESION.	ADHESION.
† Stamens.	1	Monandrous.	0
‡ Pistil.		Apocarpous.	0
Carpels.	1		

Flowers crowded on a spadix, and surrounded by a spathe. Leaves net-veined.

70. **Marsh Calla.** This plant must be looked for in low marshy grounds, where it will be found in flower generally in the month of June. With the knowledge which you have of the structure of Indian-Turnip, you will hardly doubt that the Calla is closely related to it. You will easily recognize the spadix and the spathe (Fig. 82), though in the present instance the spadix

Fig 82.

Fig. 83.

bears flowers to the top, and the spathe is open instead of enclosing the column. Observe, however, that the veining of the leaf (Fig. 83) is different, that of Calla being straight, like the Dog's-tooth Violet. There is also a difference in the flowers. Those of Indian-Turnip were found to be diœcious, but the spadix, in the present case, bears both stamens and pistils, and the lower flowers, if not all, are *perfect;* sometimes the upper ones consist of stamens only. Fig. 84 shows one of the perfect flowers much enlarged. The stamens, it will be observed, have two-celled anthers, opening lengthwise.

Fig. 84.

MARSH CALLA. Arum. family

ORGAN.	NO.	COHESION	ADHESION.
Perianth.		Wanting.	
Stamens	6	Hexandrous.	Hypogynous.
Pistil.		Apocarpous	Superior.
Carpels.	1		

71. **Showy Orchis.** The flower of this plant (Figs. 85, 86) is provided with floral envelopes, all coloured like a corolla. As in Dog's-tooth Violet, we shall call them collectively the perianth, although they are not all alike. One of them projects forward in front of the flower, forming the *lip*, and bears underneath it a long hollow *spur*, which, like the spurs of Columbine, is honey-bearing. The remaining five converge together forming a kind of arch over the centre of the flower. Each flower springs from the axil of a

Fig. 85.

leaf-like bract, and is apparently raised on a pedicel. What seems to be a pedicel, however, will, if cut across, prove to be the ovary, which in this case is inferior. Its situation is similar to the situation of the ovary in Willow-herb, and, as in that flower, so in this the calyx-tube adheres to the whole surface of the ovary, and the three outer divisions of the perianth are simply upward extensions of this tube. Notice the peculiar *twist* in the ovary. The effect of this twist is to turn the lip away

Fig. 86.

from the scape, and so give it the appearance of being the lower petal instead of the *upper* one, as it really is.

72. The structure of the stamens and pistils remains to be examined, and a glance at the flower shows you that we have here something totally different from the common arrangement of these organs. In the axis of the flower, immediately behind the opening into the spur, there is an upward projection known as the *column.* The face of this column is the stigma ; on each side of the stigma, and adhering to it, is an anther-cell. These cells, though separated by the column, constitute but a *single stamen.* The stamen, then, in this case is *united with the pistil*, a condition which is described as *gynandrous.*

73. If you have a flower in which the anther-cells are bursting open, you will see that the pollen does not issue from them in its usual dust-like form, but if you use the point of your needle carefully you may remove

Fig. 87.

the contents of each cell *in a mass.* These pollen masses are of the form shown in Fig. 87. The grains are kept together by a fine tissue or web, and the slender stalk, upon which each pollen mass is raised, is attached by its lower end to a sticky disk on the front of the stigma just above the mouth of the spur. Insects, in their efforts to reach the honey, bring their heads in contact with these disks, and when they fly away carry the pollen-masses with them, and deposit them on the stigma of the next flower visited. In fact, without the aid of insects it is difficult to see how flowers of this sort could be fertilized at all.

SHOWY ORCHIS. Orchis [illegible]

ORGAN.	NO.	COHESION.	ADHESION.	REMARKS.
Perianth.		Gamophyllous.	Superior.	
Leaves.	6			
Stamens.	1	Monandrous.	Gynandrous.	Pollen-grains collected in masses.
Pistil.		Syncarpous.	Inferior.	
Carpels.	3			Ovary twisted.

74. **Timothy.** The top of a stalk of this well-known grass is cylindrical in shape, and upon examination will be found to consist of a vast number of similar pieces compactly arranged on very short pedicels about the stalk as an axis. Carefully separate one of these pieces from the rest, and if the grass has not yet come into flower the piece will present the appearance shown in Fig. 88. In this Fig. the three points in the middle are the protruding ends of stamens. The piece which you have separated is, in fact, a flower enclosed in a pair of bracts, and all the other pieces which go to make up the top are flowers also, and, except perhaps a few at the very summit of the spike, precisely similar to this one in their structure.

Fig. 88.

75. Fig. 89 is designed to help you in dissecting a flower which has attained a greater degree of developement than the one shown in Fig. 88. Here the two bracts which enclose the flower have been drawn asunder. To these bracts the name *glumes* is applied. They are present in all

Fig. 89.

plants of the Grass Family, and are often found enclosing several flowers instead of one as in Timothy. Inside the glumes will be found a second pair of minute chaff-like bracts, which are known as *palets* or *pales*. These enclose the flower proper.

76. The stamens are three in number, with the anthers fixed by the middle to the long slender filament. The anthers are therefore *versatile*. The styles are two in number, bearing long feathery stigmas. The ovary contains a single ovule, and when ripe forms a seed-like *grain*, technically known as a *caryopsis*.

Grass Family

TIMOTHY.

ORGAN.	NO.	COHESION.	ADHESION.
Glumes.	2		
Palets.	2		
Stamens.	3	Triandrous.	Hypogynous.
Pistil.		Apocarpous.	Superior.
Carpels.	1		

CHAPTER XI.

COMMON CHARACTERISTICS OF THE PLANTS JUST EXAMINED. STRUCTURE OF THE SEED IN MONOCOTYLEDONS.

77. It is now to be pointed out that the six plants last examined, viz., Dog's-tooth Violet, Trillium, Indian Turnip, Calla, Orchis, and Timothy, though differing in various particulars, yet have some chara-

ters common to all of them, just as the group ending with Willow was found to be marked by characters possessed by all its members. The flowers of Dicotyledons were found to have their parts, as a rule, in fours or fives; those of our second group have them in *threes* or *sixes*, never in fives.

78. Again, the leaves of these plants are straight-veined, except in Trillium and Indian-Turnip, which must be regarded as exceptional, and they do not as a rule exhibit the division into petiole and blade which was found to characterize the Exogens.

79. We shall now compare the structure of a grain of Indian Corn with that of the Cucumber or Pumpkin seed which we have already examined (page 45). It will facilitate our task if we select a grain from an ear which has been boiled. And first of all, let us observe that the grain consists of something more than the seed. The grain is very much like the achene of the Buttercup, but differs in this respect, that the outer covering of the former is completely united with the seed-coat underneath it, whilst in the latter the true seed easily separates from its covering. Remove the coats of the grain, and what is left is a whitish starchy-looking substance, having a yellowish body inserted in a hollow (Fig. 90) in the middle of one side. This latter body is the *embryo*, and may be easily removed. All the rest is *albumen*. Fig. 91 is a front view of the embryo, and Fig. 92 shows a vertical section of the same. The greater part of the embryo consists of a *single cotyledon*. The radicle is seen near the base, and the plumule above.

Fig. 90. Fig. 91 Fig. 92.

80. Comparing the result of our observations with

what we have already learned about the Cucumber seed, we find that whilst in the latter there are *two* cotyledons, in the present case there is but *one*, and this peculiarity is common to all the plants just examined, and to a vast number of others besides, which are consequently designated **Monocotyledonous** plants, or shortly **Monocotyledons.** The seeds of this great Class may differ as to the presence or absence of albumen, just as the seeds of Dicotyledons do, but in the *number* of their cotyledons they are all alike. The Orchids, however, are very peculiar from having no cotyledons at all.

81. In addition to the points just mentioned, viz: the number of floral leaves, the veining of the foliage leaves, the usual absence of distinct petioles, and the single cotyledon, which characterize our second great Class, there is still another, as constant as any of these, and that is, the mode of growth of the stem, which is quite at variance with that exhibited in Dicotyledonous plants. In the present group the increase in the thickness of the stem is accomplished not by the deposition of circle after circle of new wood outside the old, but by the production of new wood-fibres through the interior of the stem generally, and the consequent swelling of the stem as a whole. These stems are therefore said to be *endogenous*, and the plants composing the group are called **Endogens**, as well as **Monocotyledons.**

We shall explain more fully the structure of exogenous and endogenous stems, when we come to speak of the minute structure of plants in a subsequent chapter.

CHAPTER XII.

MORPHOLOGY OF ROOTS, STEMS, AND FOLIAGE-LEAVES.

82. From what has gone before, you should now be tolerably familiar with the names of the different organs of plants, and you have also had your attention directed to some modifications of those organs as they occur in different plants. In all these cases, the adjective terms, which botanists use to distinguish the variations in the form of the organs, have been placed before you, and if you have committed these carefully to memory, you will have laid a good foundation for the lessons which follow on **Morphology**, the name given to the study of the various forms assumed by the same organ in different plants, or in different parts of the same plant. In some instances, the terms employed, being derived from Latin and Greek, and specially devised for botanical purposes, may seem difficult to learn. We believe, however, that this difficulty will be found to be more apparent than real. You will be surprised at the ease with which the terms will occur to your mind if you learn them with the help of plants which are everywhere within your reach—if you be not satisfied with being mere book-botanists

With a good many terms you will find no difficulty whatever, since they will be found to have the same meaning in their botanical applications as they have in their everyday use.

83. The Root. This organ is called the descending axis of the plant, from its tendency to grow downward into the soil from the very commencement of its developement. Its chief use is to imbibe liquid nourishment, and transmit it to the stem. You will remember that in our examination of some common seeds, such as those of the Pumpkin and Bean (Figs. 67-71), we found at the junction of the cotyledons a small pointed projection called the *radicle*. Now, when such a seed is put into the ground, under favourable circumstances of warmth and moisture, it begins to grow, or *germinate*, and the radicle, which in reality is a minute stem, not only lengthens, in most cases, so as to push the cotyledons upwards, but developes a *root* from its lower extremity. All seeds, in short, when they germinate, produce roots from the extremity of the radicle, and roots so produced are called *primary* roots.

84. There are two well-marked ways in which a primary root may develope itself. It may, by the downward elongation of the radicle, assume the form of a distinct central axis, from the sides of which branches or fibres are given off, or root-fibres may spring in a cluster from the end of the radicle at the very commencement of growth. If the root grow in the first way, it will be a *tap-root* (Fig. 93), examples of which are furnished by the Carrot, the Mallow, and the Bean ; if in the second way, it will be a *fibrous* root, examples of which are furnished by the Buttercup (Fig. 1) and by the entire class of Monocotyledonous or Endogenous plants.

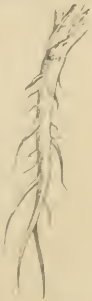

Fig. 93.

85. Tap-roots receive different names, ac-

cording to the particular shape they happen to assume. Thus, the Carrot (Fig. 94) is *conical*, because from a broad top it tapers gradually and regularly to a point. The Radish, being somewhat thicker at the middle than at either end, is *spindle-shaped.* The Turnip, and roots of similar shape, are *napiform* (*napus*, a turnip).

Fig. 94.

These fleshy tap-roots belong, as a rule, to biennial plants, and are designed as storehouses of food for the plant's use during its second year's growth. Occasionally fibrous roots also thicken in the same manner, as in the Peony, and then they are said to be *fascicled* or *clustered.* (Fig 95.)

Fig. 95.

86. But you must have observed that plants sometimes put forth roots in addition to those developed from the end of the radicle. The Verbena of our gardens, for ex-

Fig. 96.

ample, will take root at every joint, if the stem be laid upon the ground (Fig. 96). The runners of the Strawberry take root at their extremities: and nothing is more familiar than that cuttings from various plants will make roots for themselves if put into proper soil, and supplied with warmth and moisture. All such roots are produced from some other part of the stem than the radicle, and are called *secondary* or *adventitious* roots. When such roots are developed from parts of the stem which are not in contact with the ground, they are *aerial.*

87. There are a few curious plants whose roots never reach the ground at all, and which depend altogether upon the air for food. These are called *epiphytes* There are others whose roots penetrate the stems and roots of other plants, and thus receive their nourishment as it were at second-hand. These are *parasitic* plants. The Dodder, Indian-Pipe, and Beech-drops, of Canadian woods, are well-known examples.

88. **The Stem.** As the root is developed from the lower end of the radicle of the embryo, so the stem is developed from the upper end, but with this important difference, that a *bud* always precedes the formation of the stem, or any part of it or its branches. Between the cotyledons of the Bean (Fig. 71), at the top of the radicle, we found a minute bud called the *plumule.* Out of this bud the first bit of stem is developed, and during the subsequent growth of the plant, wherever a branch is to be formed, or a main stem to be prolonged, there a bud will invariably be found. The branch buds are always in the axils of leaves, and so are called *axillary. Adventitious* buds, however, are sometimes produced in plants like the Willow, particularly if the

stem has been wounded. The bud from which the main stem is developed, or a branch continued, is of course at the end of the stem or branch, and so is *terminal.*

89. If you examine a few stems of plants at random, you will probably find some of them quite soft and easily compressible, while others will be firm, and will resist compression. The stem of a Beech or a Currant is an instance of the latter kind, and any weed will serve to illustrate the former. The Beech and the Currant have *woody* stems, while the weeds are *herbaceous.* Between the Beech and the Currant the chief difference is in size. The Beech is a *tree*, the Currant a *shrub.* But you are not to suppose that there is a hard and fast line between shrubs and trees, or between herbs and shrubs. A series of plants could be constructed, commencing with an unquestionable herb, and ending with an unquestionable tree, but embracing plants exhibiting such a gradual transition from herbs to shrubs, and from shrubs to trees, that you could not say at what precise point in the series the changes occurred.

90. The forms assumed by stems above ground are numerous, and they are described mostly by terms in common use. For instance, if a stem is weak, and trails along the ground, it is *trailing*, or *prostrate;* and if, as in the runners of the Strawberry, it takes root on the lower side, then it is *creeping.* Many weak stems raise

Fig. 97.

themselves by clinging to any support that may happen to be within their reach. In some instances the stem itself winds round the support, assuming a spiral form, as in the Morning-Glory, the Hop, and the Bean, and is therefore distinguished as *twining*. In other cases the stem puts forth thread-like leafless branches called *tendrils* (Fig. 97), which grasp the support, as in the Virginia Creeper, the Grape, and the Pea (Fig. 98), or sometimes the leaf-stalks serve the same purpose, as in the Clematis or Virgin's Bower. In these cases the stems are said to *climb*.

Fig. 98.

The stems of wheat and grasses generally are known as *culms*. They are jointed, and usually hollow except at the joints.

91. Besides the stems which grow above ground, there are varieties to be found below the surface. Pull up a

Fig. 99.

Potato plant, and examine the underground portion (Fig 99). It is not improbable that you will regard the whole as a mass of roots, but a very little trouble will undeceive you. Many of the fibres are unquestionably roots, but an inspection of those having potatoes at the ends of them will show you that they are quite different from those which have not. The former will be found to be furnished with little scales, answering to leaves, each with a minute bud in the axil; and the potatoes themselves exhibit buds of the same kind. The potato, in short. is only *the swollen end of an underground stem* Such swollen extremities are known as *tubers*, whilst the underground stem is called a *rootstock*, or *rhizome*, and may always be distinguished from a true root by the presence of buds. The Solomon's Seal and Toothwort of Canadian woods, and the Canada Thistle, are common instances of plants producing these stems. Fig. 100 shows a rhizome.

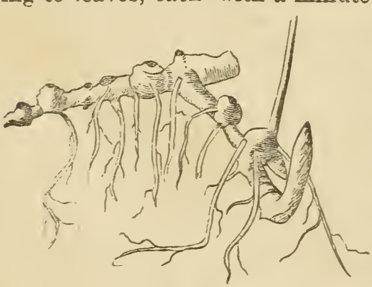

Fig. 100.

92. Take now an Onion, and compare it with a Potato. You will not find any such outside appearances upon the former as are presented by the latter. The Onion is smooth, and has no buds upon its surface. From the under side there spring roots, and this circumstance will probably suggest that the Onion must be a stem of some sort. Cut the Onion through from top to bottom (Fig. 101). It will then be seen to be

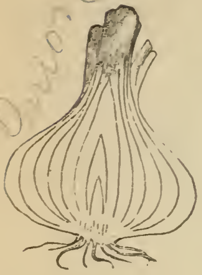

Fig 101.

made up of a number of coats. Strip off one or two, and observe that whilst they are somewhat fleshy where the onion is broadest they gradually become thinner towards the top. The long green tubes, which project from the top of the Onion during its growth, are, in fact, the prolongations of these coats. But the tubes are the leaves of the plant. The mass of our Onion, therefore, consists of the *fleshy bases of the leaves.* But you will observe that at the bottom there is a rather flat solid part upon which these coats or leaves are inserted, and which must consequently be a stem. Such a stem as this, with its fleshy leaves, is called a *bulb.* If the leaves form coats, as in the Onion, the bulb is *coated* or *tunicated;* if they do not, as in the lilies (Fig. 102), it is *scaly.*

Fig. 102

93. Tubers and bulbs, then, consist chiefly of masses of nourishing matter; but there is this difference, that, in the latter, the nourishment is contained in the fleshy leaves themselves, whilst, in the former, it forms a mass more or less distinct from the buds.

94. The thickened mass at the base of the stem of our Indian Turnip (Fig. 78) is more like a tuber than a bulb in its construction. It is called a *corm,* or solid bulb. The Crocus and Gladiolus of the gardens are other examples.

95. In the axils of the leaves of the Tiger Lily are produced small, black, rounded bodies, which, on examination, prove to be of bulbous structure. They are, in

fact, *bulblets*, and new plants may be grown from them.

96. Our Hawthorn is rendered formidable by the presence of stout *spines* (Fig. 103) along the stem and branches. These spines invariably proceed from the axils of leaves, and are, in fact, branches, whose growth has been arrested. They are appendages of the wood, and will remain attached to the stem, even after the bark is stripped off. They must not be confounded with the *prickles* (Fig. 104) of the Rose and Brier, which belong strictly to the bark, and come off with it.

Fig. 103.

Fig. 104.

97. **Foliage-Leaves.** These organs are usually more or less flat, and of a green colour. In some plants, however, they are extremely thick and succulent; and in the case of parasites, such as Indian-Pipe and Beech-drops, they are usually either white or brown, or of some colour other than green. The scaly leaves of underground stems are also, of course, destitute of colour.

98. As a general thing, leaves are extended horizontally from the stem or branch, and turn one side towards the sky and the other towards the ground. But some leaves are *vertical*, and in the case of the common Iris each leaf is doubled lengthwise at the base, and *sits astride* the next one within. Such leaves are accordingly called *equitant*.

99. As to their arrangement on the stem, leaves are *alternate* when only one arises from each node (Fig. 3). If two are formed at each node, they are sure to be

on opposite sides of the stem, and so are described as

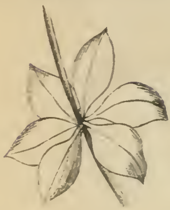

Fig. 105.

opposite. Sometimes there are several leaves at the same node, in which case they are *whorled* or *verticillate* (Fig. 105).

100. **Forms of Foliage-Leaves.** Leaves present an almost endless variety in their forms, and accuracy in describing any given leaf depends a good deal upon the ingenuity of the student in selecting and combining terms. The chief terms in use will be given here.

Compare a leaf of the Round-leaved Mallow with one of Red Clover (Figs. 106, 107). Each of them is fur-

Fig. 106.

Fig. 107.

nished with a long petiole and a pair of stipules. In the blades, however, there is a difference. The blade of the former consists of a *single piece*; that of the latter is in three separate pieces, each of which is called a *leaflet*, but all of which, taken collectively, constitute the blade

of the *leaf*. The leaf of the Mallow is **simple**; that of the Clover is **compound**. Between the simple and the compound form there is every possible shade of gradation. In the Mallow leaf the *lobes* are not very clearly defined. In the Maple (Fig. 108) they are well-marked. In other cases, again, the lobes are so nearly separate, that the leaves appear at first sight to be really compound.

Fig. 108.

101. You will remember that in our examinations of dicotyledonous plants, we found the leaves to be invariably net-veined. But, though they have this general character in common, they differ considerably in the details of their veining, or **venation**, as it is called. The two leaves employed as illustrations in the last section will serve to illustrate our meaning here. In the Mallow, there are several ribs of about the same size, radiating from the end of the petiole, something like the spread-out fingers of a hand. The veining in this case is therefore described as *digitate*, or *radiate*, or *palmate*. The *leaflet* of the clover, on the other hand, is divided exactly in the middle by a single rib (the *midrib*), and from this the veins are given off on each side, so that the veining, on the whole, presents the appearance of a feather, and is therefore described as *pinnate* (*penna*, a feather).

102. Both simple and compound leaves exhibit these two modes of venation. Of simple pinnately-veined

leaves, the Beech, Mullein, and Willow supply familiar instances. The Mallow, Maple, Grape, Currant, and Gooseberry have simple radiate-veined leaves. Sweet-Brier (Fig. 43), Mountain Ash, and Rose have compound pinnate leaves, whilst those of Virginia-Creeper (Fig. 109), Horse-Chestnut, and Hemp are compound digitate.

Fig. 109.

As has already been pointed out, the leaves of Mono-cotyledonous plants are almost invariably straight-veined.

103. In addition to the venation, the description of a simple leaf includes particulars concerning (1) the **general outline**, (2) the **edge** or **margin**, (3) the **point** or **apex**, (4) the **base**

104. **Outline.** As to outline, it will be convenient to consider first the forms assumed by leaves without lobes, and whose margins are therefore more or less continuous. Such leaves are of three sorts, viz : those in which both ends of the leaf are alike, those in which the apex is narrower than the base, and those in which the apex is broader than the base.

105. In the first of these three classes, it is evident that any variation in the outline will depend altogether on the relation between the length and the breadth of the leaf. When the leaf is extremely narrow in comparison with its length, as in the Pine, it is *acicular* or *needle-shaped* (Fig. 110). As the width increases, we pass through the forms known as *linear, oblong, oval,* and finally *orbicular,* in which the width and length are nearly, or quite equal (Fig. 111).

Fig. 110

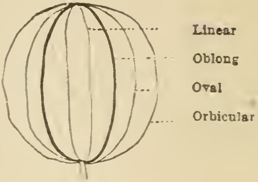

Fig. 111.

106. In the second class the different forms arise from the varying width of the base of the leaf, and we thus have *subulate* or *awl-shaped* (Fig. 112), *lanceolate, ovate*, and *deltoid* leaves (Fig. 113).

Fig. 112.

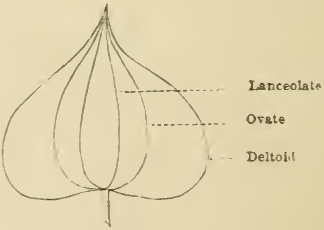

Fig. 113.

107. In the third class, as the apex expands, we have

Fig. 117

Fig. 118.

Fig. 114.

Fig. 115.

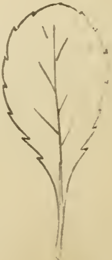

Fig. 116.

the forms *spathulate* (Fig. 114), *oblanceolate* (that is, the reverse of lanceolate) (Fig. 115), and *obovate* (Fig. 116).

108. In leaves of the second kind we frequently find the base indented, and then the leaf is *cordate*, or *heart-shaped* (Fig. 117). The reverse of this, that is, when the indentation is at the apex, is *obcordate* (Fig. 118). The *hastate*, or spear-shaped (Fig. 119), *sagittate*, or arrow-shaped (Fig. 120), and *reniform*, or kidney-shaped (Fig. 121), forms are modifications of the second class, and will be readily understood from the annexed figures.


Fig. 119.

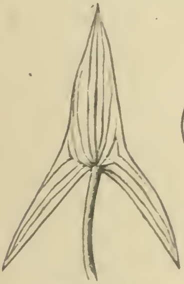
Fig. 120.


Fig. 121.


Fig. 122.

If the petiole is attached to any part of the under surface of the leaf, instead of to the edge, the leaf is *peltate* (shield-shaped) (Fig. 123).


Fig. 123.

109. Leaves which are lobed are usually described by stating whether they are palmately or pinnately veined, and, if the former, the number of lobes is generally

given. If the leaves are very deeply cut, they are said to be *palmatifid* or *pinnatifid* according to the veining (Fig. 124). If the leaf is palmately lobed, and the lobes at the base are themselves lobed, the leaf is *pedate* (Fig. 125), because it looks something like a bird's foot. If the lobes of a pinnatifid leaf are themselves lobed, the leaf is *bipinnatifid*. If the leaf is cut up into fine segments, as in Dicentra, it is said to be *multifid*.

Fig. 124.

110. **Apex.** The principal forms of the apex are the *mucronate* (Fig. 122), when the leaf is tipped with a sharp point, as though the midrib were projecting beyond the blade; *cuspidate*, when the leaf ends abruptly in a very short, but distinctly tapering, point (Fig. 126); *acute*, or sharp; and *obtuse*, or blunt.

Fig. 125.

111. It may happen that the apex does not end in a point of any kind. If it looks as though the end had been cut off square, it is *truncate*. If the end is slightly notched, but not sufficiently so to warrant the description obcordate, it is *emarginate*.

Fig. 126.

112. **Margin.** If the margin is not indented in any way, it is said to be *entire*. If it has sharp teeth, *pointing in the direction of the apex*, it is *serrate*, and will be coarsely or finely serrate, according to the size of the


Fig. 127.

teeth. Sometimes the edges of large teeth are themselves finely serrated, and in that case the leaf is *doubly serrate* (Fig. 127). If the teeth point *outwards*, that is, if the two edges of each tooth are of the same length, the leaf is *dentate*, but if the teeth, instead of being sharp, are *rounded*, the leaf is *crenate* (Fig. 128). The term *wavy* explains itself.


Fig. 128

113. **Base.** There are two or three peculiar modifications of the bases of simple sessile leaves which are of considerable importance in distinguishing plants. Sometimes a pair of lobes project backwards and cohere on the other side of the stem, so that the stem appears to pass through the leaf. This is the case in our common Bellwort, the leaves of which are accordingly described as *perfoliate* (Fig. 129). Sometimes two opposite sessile leaves grow together at the base, and clasp the stem, as in the upper leaves of Honeysuckle, in the Triosteum, and in one of our species of Eupatorium. Such leaves are said to be *connate* or *connate-perfoliate* (Fig. 130). In one of our Everlastings the margin of the leaf is continued on each side below the


Fig. 129.


Fig. 130.


Fig. 131.

point of insertion, and the lobes grow fast to the sides

of the stem, giving rise to what is called the *decurrent* form (Fig. 131).

The terms by which simple leaves are described are applicable also to the leaflets of compound leaves, to the sepals and petals of flowers, and, in short, to any flat forms.

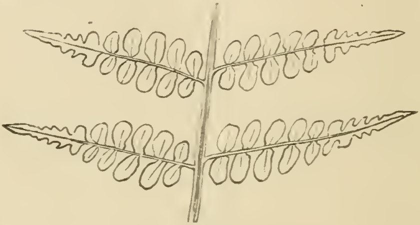

Fig. 132.

114. We have already explained that compound leaves are of two forms, *pinnate* and *palmate.* In the former, the leaflets are arranged on each side o the midrib. There may be a leaflet at the end, in which case the leaf is *odd-pinnate*, or the terminal leaflet may be wanting, and then the leaf is *abruptly pinnate.* In the Pea, the is pinnate and terminates in a *tendril* (Fig. 98). Very frequently the primary divisions of a pinnate leaf are themselves pinnate, and the whole leaf is then *twice-pinnate* (Fig. 132). If the subdivision is continued through another stage, the leaf is *thrice-pinnate*, and so on. Sometimes, as in the leaves of the Tomato, very small leaflets are found between the larger ones, and this form is described as *interruptedly pinnate* (Fig. 133).

Fig. 133.

In the palmate or digitate forms, the leaflets spread out from the end of the petiole, and, in describing them, it is usual to mention the number of divisions. If there are three, the leaf is *tri-foliolate*; if there are five, it is *quinquefoliolate*.

115. In the examination of the Mallow, we found a couple of small leaf-like attachments on the petiole of each leaf, just at the junction with the stem. To these the name *stipules* was given. Leaves which have not these appendages are *exstipulate*.

116. Besides the characters of leaves mentioned above, there remain a few others to be noticed. With regard to their **surface**, leaves present every gradation from perfect smoothness, as in Wintergreen, to extreme roughness or woolliness, as in the Mullein. If hairs are entirely absent, the leaf is *glabrous*; if present, the degree of hairiness is described by an appropriate adverb; if the leaf is completely covered, it is *villous* or *villose*; and if the hairs are on the margin only, as in our Clintonia, it is *ciliate*. Some leaves, like those of Cabbage, have a kind of bloom on the surface, which may be rubbed off with the fingers; this condition is described as *glaucous*.

Fig. 134.

117. A few plants have **anomalous leaves**. Those of the Onion are *filiform*. The Pitcher Plant of our Northern swamps has very curious leaves (Fig. 134), apparently formed by the turning in and cohesion of the outer edges of an ordinary leaf, so as to form a tube, closed except at the top, and armed

Mrs. Taylor Mitchell

on the inner surface with bristles pointing towards the base of the leaf.

118. Finally, as leaves present an almost infinite variety in their forms, it will often be necessary, in describing them, to combine the terms explained above. For instance, a leaf may not be exactly linear, nor exactly lance-shaped, but may approximate to both forms. In such a case the leaf is described as *lance-linear*, and so with other forms.

The following form of schedule may be used with advantage in writing out descriptions of leaves. Two leaves—one of Maple and one of Sweet-Brier—are described by way of illustration. If a leaf is compound, the particulars as to outline, margin, apex, base, and surface will have reference to the leaflets.

LEAF SCHEDULE.

Leaf of	Maple.	Sweet-Brier.
1. Position.	Cauline.	Cauline.
2. Arrangement.	Opposite.	Alternate.
3. Insertion.	Petiolate.	Petiolate.
4. Stipulation.	Exstipulate.	Stipulate.
5. Division.	Simple.	Odd pinnate, 7 leaflets.
6. Venation.	Palmate.	
7. Outline.		Roundish or oval.
8. Margin.	Deeply lobed.	Doubly serrate.

9. Apex.	Pointed.	Acute.
10. Base.	Cordate.	Hardly indented.
11. Surface.	Glabrous above; whitish beneath.	Downy above; covered with glands beneath.

CHAPTER XIII.

MORPHOLOGY OF FLOWER-LEAVES. THE CALYX. THE COROLLA. THE STAMENS. THE PISTIL. THE FRUIT. THE SEED. GERMINATION.

119. From an examination of the various forms presented by foliage leaves, we proceed now to those of the floral ones, and we shall first consider the chief modifications in the *arrangement of flowers as a whole*, to which the term **inflorescence** is applied.

120. It is found that inflorescence proceeds upon two well-defined plans. To understand these, let us recur to our specimens of Shepherd's-Purse and Buttercup. You will remember that, in the former, the peduncle continues to lengthen as long as the summer lasts, and new flowers continue to be produced at the upper end. Observe, however, that every one of the flowers is produced *in the axil of a bract*, that as the stem lengthens new bracts appear, and that *there is no flower on the end of the stem.* You will easily understand then, that the production of flowers in such a plant is only limited by the close of the season or by the exhaustion of the plant. Such inflorescence is therefore called **indefinite** or **indeterminate**, or **axillary**. It is sometimes also called *centripetal*, because if the flowers happen to be in a close cluster, as are the upper

ones in Shepherd's-Purse, the order of developement is from the outside *towards the centre.*

121. If you now look at your Buttercup, you will be at once struck with the difference of plan exhibited. The main axis or stem has *a flower on the end of it*, and its further growth is therefore checked. And so in like manner, from the top downwards, the growth of the branches is checked by the production of flowers at their extremities. The mode of inflorescence here displayed is **definite**, or **determinate**, or **terminal**. It is also called *centrifugal*, because the developement of the flowers is the reverse of that exhibited in the first mode. The upper, or, in the case of close clusters, the *central* flowers open first. In either mode, if there is but one flower in each axil, or but one flower at the end of each branch, the flowers are said to be *solitary*.

122. Of **indeterminate inflorescence** there are several varieties. In Shepherd's-Purse we have an instance of the *raceme*, which may be described as a cluster in which each flower springs from an axil, and is supported on a pedicel of its own. If the pedicels are absent, and the flowers consequently sessile in the axils, the cluster becomes a *spike*, of which the common Plantain and the Mullein furnish good examples. The *catkins* of the Willow (Figs. 63, 64) and Birch, and the *spadix* of the Indian Turnip (Figs. 80, 81) are also spikes, the former having scaly bracts and the latter a fleshy axis. If you suppose the internodes of a spike to be suppressed, so that the flowers are densely crowded, you will have a *head*, of which Clover and Button-bush supply instances. If the lower pedicels of a raceme are considerably longer than the upper ones, so that all the blossoms are nearly on the same

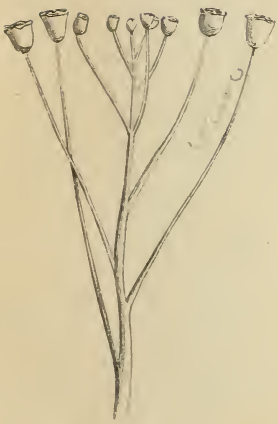

Fig. 135.

Fig. 136.

level, the cluster is a *corymb* (Fig. 135). If the flowers in a head were elevated on separate pedicels of the same length, radiating like the ribs of an umbrella, we should have an *umbel*, of which the flowers of Geranium and Parsnip (Fig. 49) are examples. A raceme will be *compound* (Fig. 136) if, instead of a solitary flower, there is a *raceme in each axil*, and a similar remark will apply in the case of the spike, the corymb, and the umbel.

123. The inflorescence of most Grasses is what is called a *panicle.* This is a compound form, and is usually a kind of raceme having its primary divisions branched in some irregular manner. If the panicle is

compact, as in the Grape and Lilac, it is what is called a *thyrse.*

124. Of **determinate inflorescence** the chief modification is the *cyme.* This is a rather flat-topped cluster, having something the appearance of a compound corymb, but easily distinguished by this peculiarity, that the *central blossom opens first*, then those at the ends of the first set of branches of the cluster, then those on the secondary branches, and so on until the outer buds are reached. The Elder, Dogwood, and St. John's Wort furnish good examples of the cymose

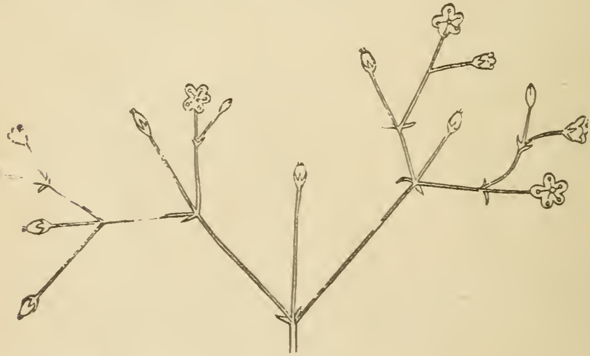

Fig. 137.

structure. Fig. 137 shows a loose open cyme.

125. It has already been pointed out that cauline leaves tend to diminish in size towards the upper part of the stem, where the flowers are found. Such reduced leaves, containing flowers in their axils, are called *bracts.* In the case of compound flower-clusters, this term is limited to the leaves on the peduncle, or main stem, the term *bractlet* being then applied to those occurring on the pedicels or subordinate stems. In the

case of the *umbel* and the *head*, it generally happens that a *circle* of bracts surrounds the base of the cluster. They are then called, collectively, an *involucre*, and in the case of compound clusters a circle of bractlets is called an *involucel*. Bracts are often so minute as to be reduced to mere *scales*. From our definition, it will be evident that the *spathe* surrounding the spadix in Indian Turnip is merely a bract.

126. It has already been stated that the parts of the flower, equally with the foliage-leaves, must be regarded as modifications of the same structure, and some proofs of this similarity of structure were given. We shall now proceed to consider in detail the variations in form assumed by these organs.

127. **The Calyx.** As you are now well aware, this term is applied to the outer circle of floral leaves. These are usually green, but not necessarily so; in some Exogens, and in nearly all Endogens, they are of some other colour. Each division of a calyx is called a *sepal*, and if the sepals are entirely distinct from each other, the calyx is *polysepalous*; if they are united in any degree, it is *gamosepalous*. A calyx is *regular* or *irregular*, according as the sepals are of the same or different shape and size.

128. In a gamosepalous calyx, if the sepals are not united to the very top, the free portions are known as *calyx-teeth*, or, taken collectively, as the *limb* of the calyx. The united portion, especially if long, as in Willow-herb, is called the *calyx-tube*, and the entrance to the tube its *throat*. In many plants, particularly those of the Composite Family, the limb of the calyx consists merely of a circle of bristles or soft hairs,

and is then described as *pappose*. In other cases the limb is quite inconspicuous, and so is said to be *obsolete.* A calyx which remains after the corolla has disappeared, as in Mallow (Fig. 31), is *persistent*. If it disappears when the flower opens, as in our Bloodroot, it is *caducous*, and if it falls away with the corolla, it is *deciduous.*

We must repeat here, that when calyx and corolla are not both present, the circle which is present is considered to be the calyx, whether green or not.

129. **The Corolla.** The calyx and corolla, taken together, are called the *floral envelopes*. When both envelopes are present, the corolla is the inner one; it is usually, though not invariably, of some other colour than green. Each division of a corolla is called a *petal*, and the corolla is *polypetalous* when the petals are completely disconnected; but *gamopetalous* if they are united in any degree, however slight. The terms *regular* and *irregular*, applied to the calyx, are applicable also to the corolla, and the terms used in the description of leaves are applicable to petals. If, however, a petal is narrowed into a long and slender portion towards the base, that portion is known as the *claw*, whilst the broader upper part is called the *limb* (Fig. 138). The leaf-terms are then applicable to the limb.

Fig. 138.

130. Gamopetalous corollas assume various forms, most of which are described by terms easily understood. The forms assumed depend almost entirely on the shape of the petals which, when united, make up the corolla. If these, taken separately, are linear, and are

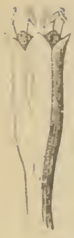

Fig 139

united to the top, or nearly so, the corolla will be tubular (Fig. 139.) If the petals are wedge-shaped, they will by their union produce a *funnel-shaped* corolla. (Fig. 140.) In the *campanulate* or *bell-shaped* form, the enlargement from base to summit is more gradual. If the petals are narrowed abruptly into long claws, the union of the claws into a tube and the spreading of the limb at right angles to the tube will produce the *salver-shaped* form, as in Phlox (Fig. 141). The *rotate* corolla differs from this in having a *very short* tube. The corolla of the Potato is rotate.

Fig. 140.

131. The most important *irregular* gamopetalous corollas are the *ligulate*, which has been fully described in the examination of the Dandelion, and the *labiate*, of which we found an example in Catnip (Fig. 59). The corolla of Turtle-head (Fig. 142) is another example. When a labiate corolla presents a wide opening between the upper and lower lips, it is said to be *ringent*, if the opening is closed by an

Fig. 141.

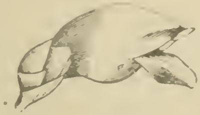

Fig. 142.

Fig. 143.

upward projection of the lower lip, as in Toadflax (Fig. 143), it is said to be *personate*, and the projection in

this case is known as the *palate*. A good many corollas such as those of Toadflax, Dicentra, Snapdragon, Columbine, and Violet, have protuberances or *spurs* at the base. In Violet one petal only is spurred; in Columbine the whole five are so.

132. **The Stamens.** As calyx and corolla are called collectively the floral envelopes, so stamens and pistil are spoken of collectively as the *essential organs* of the flower. The circle of stamens alone is sometimes called the *andræcium*. A complete stamen consists of a slender stalk known as the *filament*, and a small sac called the *anther*. The filament, however, is not uncommonly absent, in which case the anther is *sessile*. As a general thing, the anther consists of two oblong cells with a sort of rib between them called the *connective*, and that side of the anther which presents a distinctly *grooved* appearance is the *face*, the opposite side being the *back*. The filament is invariably attached to the connective, and may adhere through the entire length of the latter, in which case the anther is *adnate*

Fig. 144.

Fig. 145.

Fig. 146.

(Fig. 144), or the base of the connective may rest on the end of the filament, a condition described as *innate* (Fig. 145), or the extremity of the filament may be attached to the middle of the back of the connective, so that the anther swings about; it is then said to be *versatile* (Fig. 146). In all these cases, if the face of

the anther is turned towards the centre of the flower, it is said to be *introrse*; if turned outwards, *extrorse*.

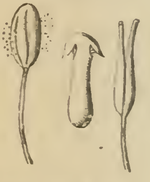

Fig. 147. Fig. 149. Fig. 148.

133. The cells of anthers commonly open along their outer edges to discharge their pollen (Fig. 147). In most of the Heaths, however, the pollen is discharged through a minute aperture at the top of each cell (Fig. 148), and in our Blue Cohosh each cell is provided with a lid or valve near the top, which opens on a kind of hinge (Fig. 149).

134. Stamens may be either entirely distinct from each other, in which case they are described as *diandrous*, *pentandrous*, *octandrous*, &c., according to their number (or, if more than twenty, as indefinite), or they may be united in various ways. If their anthers are united in a circle, while the filaments are separate (Fig. 94), they are said to be *syngenesious*, but if the filaments unite to form a tube, while the anthers remain distinct, they are said to be *monadelphous* (Fig. 82); if they are in two groups they are *diadelphous* (Fig. 87); if in three, *triadelphous*; if in more than three, *polyadelphous*.

135. As to **insertion**, when stamens are inserted on the receptacle, they are *hypogynous*; when borne on the calyx, *perigynous*; when borne on the ovary, *epigynous*; and if inserted on the corolla, *epipetalous*. They may, however, be borne even on the style, as in Orchis, and then they are described as *gynandrous*.

136. If the stamens are four in number, and in two pairs of different lengths, they are said to be *didynamous* (Fig. 98); if six in number, four long and two short, they are *tetradynamous* (Fig. 90), and, finally,

if the stamens are hidden in the tube of a gamopetalous corolla, they are said to be *included*, but if they protrude beyond the tube they are *exserted* (Fig. 139).

137. **The Pistil.** This is the name given to the central organ of the flower. It is sometimes also called the *gynæcium*. As in the case of the stamens, the structure of the pistil must be regarded as a modification of the structure of leaves generally. The pistil may be formed by the folding of a single carpellary leaf as in the Bean (Fig. 159), in which case it is *simple*; or it may consist of a number of carpels, either entirely separate from each other, or united together in various ways, in which case it is *compound*. If the carpels are entirely distinct, as in Buttercup, the pistil is *apocarpous*; if they are united in any degree, it is *syncarpous*.

138. In our examination of the Marsh Marigold (Figs. 24, 25) we found an apocarpous pistil of several carpels. We found also that each carpel contained a number of seeds, and that, in every case, the seeds were attached to that edge of the carpel *which was turned towards the centre of the flower*, and that, as the carpels ripened, they invariably split open along that edge, but not along the other, so that the carpel when opened out presented the appearance of a leaf with seeds *attached to the margins*. The inner edge of a simple carpel, to which the seeds are thus attached, is called the *ventral suture*, the opposite edge, corresponding to the mid-rib of a leaf, being the *dorsal suture*.

139. If we suppose a number of simple carpels to approach each other, and unite in the centre of a flower, it is evident that the pistil so formed would contain as many cells as there were carpels, the cells being separ-

ated from each other by a *double wall*, and that the seeds would be found arranged about the centre or axis of the pistil; and this is the actual state of things in the Tulip, whose pistil is formed by the union of three carpels. When the pistil ripens, the double walls separating the cells split asunder. To these separating walls the name *dissepiment* or *partition* is given.

140. But it often happens that though several carpels unite to form a compound pistil, there is but *one cell* in the ovary. This is because the separate carpellary leaves have not been folded before uniting, have been joined edge to edge, or rather with their edges slightly turned inwards. In these cases the seeds cannot, of course, be in the centre of the ovary, but will be found

Fig. 151.

Fig. 150.

on the walls, at the junction of the carpels (Figs. 150, 151). In some plants the ovary is one-celled, and the seeds are arranged round a column which rises from the bottom of the cell (Figs. 152, 153). This case is explained by the early obliteration of the partitions, which must at first have met in the centre of the cell.

Figs. 152, 153.

141. In all cases the line or projection to which the seeds are attached is called the *placenta*, and the term placentation has reference to the manner in which the placentas are arranged. In the simple pistil the placentation is *marginal* or *sutural*. In the syncarpous pistil, if the dissepiments meet in the centre of the ovary, thus dividing it into separate cells, the placentation is *central* or *axile*; if the ovary is one-celled and bears the seeds on its walls, the placentation is *parietal*.

and if the seeds are attached to a central column, it is *free central.*

142. Besides the union of the ovaries there may also be a union of the styles, and even of the stigmas.

143. A very exceptional pistil is found in plants of the Pine Family. Here the ovules, instead of being enclosed in an ovary, are usually simply attached to the inner surface of an open carpellary leaf or scale, the scales forming what is known as a *cone* (Figs. 154, 155, 156). The plants of this family are hence called *gymnospermous*, or naked-seeded.

Fig. 154.

Figs. 155, 156.

144. **The Fruit.** In coming to the consideration of the Fruit, you must for the present lay aside any popular ideas you may have acquired as to the meaning of this term. You will find that, in a strict botanical sense, many things are fruits which, in the language of common life, are not so designated. For instance, we hardly speak of a pumpkin or a cucumber as fruit, and yet they are clearly so, according to the botanist's definition of that term. A fruit may be defined to be *the ripened pistil together with any other organ, such as the calyx or receptacle, which may be adherent to it.* This definition will perhaps be more clearly understood after a few specimens have been attentively examined.

145. For an example of the simplest kind of fruit let us revert to our Buttercup. As the carpels ripen, the style and stigma are reduced to a mere point. On cutting open one of these carpels when fully ripe, we find it contains a single seed, not quite filling the cavity, but attached at one point to the wall of the latter. What you have to guard against, in this

instance, is the mistake of considering the entire carpel to be merely a seed. It is a seed enveloped in an outer covering which we called the ovary in the early stages of the flower, but which, now that it is ripe, we shall call the *pericarp*. This pericarp, with the seed which it contains, is the fruit. The principal difference between the fruit of Marsh-Marigold and that of Buttercup is, that, in the former, the pericarp envelopes several seeds, and, when ripe, *splits open down one side*. The fruit of Buttercup does not thus split open. In the Pea, again, the pericarp encloses several seeds, but splits open along *both* margins. The fruits just mentioned all result from the ripening of *apocarpous* pistils, and they are consequently spoken of as *apocarpous fruits*.

146. In Willow-herb, you will recollect that the calyx tube adheres to the whole surface of the ovary. The fruit in this case, then, must include the calyx. When the ovary ripens, it splits longitudinally into four pieces (Fig. 41), and, as the pistil was *syncarpous*, so also is the fruit.

147. In the Peach, Plum, Cherry, and *stone-fruits* or *drupes* generally, the seed is enclosed in a hard shell called a *putamen*. Outside the putamen is a thick layer of pulp, and outside this, enclosing the whole, is a skin-like covering. In these fruits all outside the seeds is the pericarp. In one respect these stone-fruits resemble the fruit of the Buttercup: they do not split open in order to discharge their seeds. All fruits having this peculiarity are said to be **indehiscent**, whilst those in which the pericarp opens, or separates into pieces (called *valves*), are **dehiscent**.

148. In the Apple (Fig. 48) and Pear, the seeds are contained in five cells in the middle of the fruit, and these cells are surrounded by a firm fleshy mass which is an enlargement of the calyx. In fact, the remains of the five calyx-teeth may be readily detected at the end of the apple opposite the stem. As in Willow-herb, the calyx is adherent to the ovary, and therefore calyx and ovary together constitute the pericarp. These *fleshy-fruits*, or *pomes*, as they are sometimes called, are of course *indehiscent*.

149. In the Currant, as in the Apple, you will find the remains of a calyx at the top, so that this fruit, too, is *inferior*, but the seeds, instead of being separated from the mass of the fruit by tough cartilaginous cell-walls, as in the Apple, lie imbedded in the soft juicy pulp. Such a fruit as this is a *berry*. The Gooseberry and the Grape are other examples. The Pumpkin and other *gourds* are similar in structure to the berry, but besides the soft inner pulp they have also a firm outer layer and a hard rind. The name *pepo* is generally given to fruits of this sort.

Fig. 157.

150. A Raspberry or Blackberry (Fig. 157) proves, on examination, to be made up of a large number of juicy little drupes, aggregated upon a central axis. It cannot, therefore, be a true berry, but may be called an *aggregated* fruit.

151. A Strawberry (Fig. 158) is a fruit, consisting chiefly of a mass of pulp, having its surface dotted over with little carpels (achenes) similar to those of the Buttercup. The flesh of the Strawberry

Fig. 158.

is simply an enlarged *receptacle* ; so that this fruit, also, is not a true berry.

152. The fruit of Sweet-Brier (Fig. 155) consists of a red fleshy calyx, lined with a hollow receptacle which bears a number of achenes. This fruit is therefore analogous to that of the Strawberry. In the latter the achenes are on the outer surface of a *raised* receptacle, while, in the former, they are on the inner surface of a *hollow* receptacle.

153. The Cone of the Pine (Fig. 154) is a fruit which differs in an important respect from all those yet mentioned, inasmuch as it is the product, not of a single flower, but of as many flowers as there are scales. It may therefore be called a *collective* or *multiple* fruit. The Pine-Apple is another instance of the same thing.

154. Of dehiscent fruits there are some varieties which receive special names. The fruit of the Pea, or Bean (Fig. 159), whose pericarp splits open along *both* margins, is called a *legume* ; that of Marsh-Marigold (Fig. 25), which opens down one side only, is a *follicle*. Both of these are apocarpous.

Fig. 159.

155. Any syncarpous fruit, having a dry *dehiscent* pericarp, is called a *capsule*. A long and slender capsule, having two cells separated by a membranous partition bearing the seed, and from which, when ripe, the valves fall away on each side, is called a *silique*

(Fig. 160). If, as in Shepherd's Purse (Fig. 29), the capsule is short and broad, it is called a *silicle*. If the capsule opens *horizontally*, so that the top comes off like a lid, as in Purslane (Fig. 161), it is a *pyxis*.

Fig. 161.

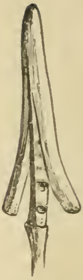

Fig. 160.

156. Any dry, one-seeded, *indehiscent* fruit is called an *achene*, of which the fruit of Buttercup (Fig. 14) is an example. In Wheat the fruit differs from that of Buttercup in having a closely fitting and *adherent* pericarp. Such a fruit is called a *caryopsis* or *grain*. A *nut* is usually syncarpous, with a hard, dry pericarp. A *winged* fruit, such as that of the Maple (Fig. 162), is called a *samara* or *key*.

Fig. 162.

157. **The Seed.** The seed has already been described as the *fertilized ovule*. It consists of a *nucleus*, enveloped, as a rule, in two coats. The outer one, which is the most important, is known as the *testa*. Occasionally an additional outer coat, called an *aril*, is found. In the Euonymus of Canadian woods, the aril is particularly prominent in autumn, owing to its bright scarlet colour. The stalk, by which the seed is attached to the placenta, is the *funiculus*, and the scar, formed on the testa where it separates from the seed-stalk, is called the *hilum*. In the Pea and the Bean this scar is very distinct.

158. **Germination of the Seed.** When a seed is lightly covered with earth, and supplied with warmth and moisture, it soon begins to swell and soften, owing to the absorption of water, and presently bursts its

coats, either to such a degree as to liberate the cotyledons completely, or so as to permit the escape of the radicle and the plumule. The former immediately takes a downward direction, developing a root from its lower end, and either elongates through its whole length, in which case the cotyledons are pushed above the surface, as in the Bean, or remains stationary, in which event the cotyledons remain altogether under ground, as in the Pea and in Indian Corn.

Before the root is developed, and the little plantlet is thereby enabled to imbibe food from the soil, it has to depend for its growth upon a store of nourishment supplied by the parent plant before the seed was cast adrift. The relation of this nourishment to the embryo is different in different seeds. In the Bean and the Pumpkin, for example, it is contained in the cotyledons of the embryo itself. But in Indian Corn, as we have already seen, it constitutes the bulk of the seed, the embryo merely occupying a hollow in one side of it. In such cases as the latter, it will be remembered that the term *albumen* is applied to the nourishing matter, as distinguished from the embryo.

159. As to the number of cotyledons, it may be repeated that, as a rule, seeds are either dicotyledonous or monocotyledonous. Some plants of the Pine Family, however, exhibit a modification of the dicotyledonous structure, having several cotyledons, and being consequently distinguished as *polycotyledonous*.

CHAPTER XV.

ON THE MINUTE STRUCTURE OF PLANTS—EXOGENOUS AND ENDOGENOUS STEMS—FOOD OF PLANTS.

160. Up to this point we have been engaged in observing such particulars of structure in plants as are manifest to the naked eye. It is now time to enquire a little more closely, and find out what we can about the *elementary* structure of the different organs. We have all observed how tender and delicate is a little plantlet of any kind just sprouting from the seed; but as time elapses, and the plant develops itself and acquires strength, its substance will, as we know, assume a texture varying with the nature of the plant, either becoming hard and firm and woody, if it is to be a tree or a shrub; or continuing to be soft and compressible as long as it lives, if it is to be an herb. Then, as a rule, the leaves of plants are of quite a different consistency from the stems, and the ribs and veins and petioles of foliage leaves are of a firmer texture than the remaining part of them. In all plants, also, the newest portions, both of stem and root, are extremely soft compared with the older parts. It will be our object in this chapter to ascertain, as far as we can, the reason of such differences as these; and to accomplish this, we shall have to call in the aid of a microscope of much higher power than that which has hitherto served our purpose.

161. If a small bit, taken from a soft stem, be boiled for a while so as to reduce it to a pulp, and a little of this pulp be examined under the microscope, it will be found to be entirely composed of more or less rounded

or oval bodies, which are either loosely thrown together (Fig. 163), or are pressed into a more or less compact

Fig. 163.

Fig. 164.

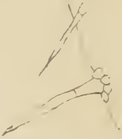

Fig. 164 *(a)*.

mass. In the latter case, owing to mutual pressure, they assume a somewhat angular form. These bodies are called *cells*. They are hollow, and their walls are usually thin and transparent. The entire fabric of every plant, without any exception whatever, is made up of cells; but as we proceed in our investigation, we shall find that these cells are not all precisely alike, that as they become older they tend, as a rule, to thicken their walls and undergo changes in form, which, to a great extent, determine the texture of the plant's substance.

162. A fabric made up of cells is called a *tissue*. A collection of such cells as we found constituting our pulp, and as we should find constituting the mass of all the soft and new parts of plants, as well as of some hard parts, is called *cellular tissue*. The cells composing cellular tissue vary a great deal in size in different plants, being, as a rule, largest in aquatics, in which they may sometimes be observed with the naked eye. Ordinarily, however, they are so minute that millions of them find room in a cubic inch of tissue.

163. When young, the walls of the cells are quite unbroken. Each cell is lined with an extremely thin membrane, and a portion of its cavity is occupied by a

Drawing of cell cellulose protoplasm cell sap.

soft body called the *nucleus*. The space between the nucleus and the lining of the cell is filled with a thickish liquid called *protoplasm*, and the microscope reveals to us the fact that, as long as the cells are *living* cells, a circulation or current is constantly kept up in the protoplasm of each. To this curious movement the term *cyclosis* has been applied. As the cells become older, the nature of their contents is altered by the introduction of watery sap, in which other substances are found, notably starch, sugar, chlorophyll (to which leaves owe their green colour), and crystals (raphides) of various salts of lime. The substance of which the cell-wall is composed is called *cellulose*, and is a chemical compound of carbon, hydrogen, and oxygen. In the protoplasm nitrogen is found in addition to the three elements just mentioned.

164. *The growth of a plant consists in the multiplication of its cells.* Every plant begins its existence with a single cell, and by the repeated division of this, and the growth of the successive sections, the whole fabric of the plant, whether herb, shrub, or tree, is built up. The division of a cell is accomplished by the formation of a partition across the middle of it, the nucleus having previously separated into two pieces. The partition is formed out of the *lining* of the cell. Each half of the cell then enlarges, and, when its full size is attained, divides again, and so on, as long as the cells are *living* cells.

165. But in order to increase their size, *food* of some kind is essential. Growing plants supply this to their cells mainly in the form of sap, which is taken in by the root-fibres, and made suitable, or *elaborated*, or *assimilated*, by chemical action in the plant itself. By

H 20 O10 = cellulose, same chemi...
formulae for St...

a very curious process, the liquids absorbed by the root pass from cell to cell, though each is quite enclosed, until they reach the leaves, where the elaboration is performed. The process is carried on under the law, that if two liquids of different density be separated by a thin or porous diaphragm, they will permeate the diaphragm, and change places with greater or less rapidity according to circumstances, the liquid of *less* density penetrating the diaphragm more rapidly than the other. The cells of plants, as we have said, contain dense liquid matter. The moisture present in the soil, and in contact with the tender root-hairs (which are made up of cells, you will remember), being of less density than the contents of the cells, flows into them, and is then passed on from cell to cell on the same principle. The supply of assimilated matter is thus renewed as fast as it is appropriated by the newly divided and growing cells.

166. If a plant, during its existence, simply multiplies its cells in this way, it can of course only be a mass of cellular tissue as long as it lives. But we see everywhere about us plants, such as trees and shrubs, whose stems are extremely firm and enduring. How do these stems differ from those of tender herbs? How do they differ from the soft parts of the plants to which they themselves belong? A moment's consideration will make it evident that, as every plant begins with a single cell, and increases by successive multiplications of it, every part of the plant must at some time have been composed of cellular tissue, just as the newer portions are at present. The cells of those parts which are no

Wall cells are sometimes called Primordial cells

longer soft must, then, have undergone a change of some kind. Let us try to understand the nature of this change. It has been stated that the walls of new cells are extremely thin; as they become older, however, they, as a rule, increase in thickness, owing to deposits of cellulose upon their inner surface. It sometimes happens, indeed, that the deposits are so copious as to almost completely fill up the cavity of the cell. The idea will naturally suggest itself, that this thickening of the walls must impede the passage of the sap, but it is found that the thickening is not uniform, that there are, in fact, regular intervals which remain thin, and that the thin spot in one cell is directly opposite a corresponding thin spot in the wall of its neighbour. Eventually, however, these altered cells cease to convey sap.

167. The hard parts of plants, then, differ from the soft parts in the different *consistency of their cell-walls.* But they differ also in the *form of the cells themselves.* In those parts where toughness and strength will be required, as, for example, in the inner bark, in the stem, and in the frame-work of the leaves, the cells become elongated and their extremities assume a tapering form, so that they overlap each other, instead of standing end to end as in ordinary cellular tissue (Fig. 165). To this drawing-out process, combined with the hardening of the walls, is due the firmness of wood generally, and the tissue formed by these modified cells is known as *woody tissue.* On account of the great relative length of the cells found in the inner

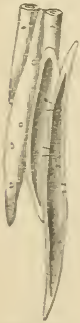

Fig. 165.

bark, and the consequent toughness conferred upon that part, the tissue formed by them is specially distinguished as *bast* tissue. Associated with the wood-cells are commonly found others, differing from them chiefly in being larger in diameter, and formed out of rows of short cells, standing end to end, by the disappearance of the partitions which separated them. These enlarged cells, produced in this way, are called *vessels* or *ducts*, and a combination of them is known as *vascular tissue*. Ducts invariably show markings of some sort on their walls. The one figured in the margin (Fig. 106) is a *dotted* duct, the dots being spaces which have not been thickened by deposits of cellulose. Other ducts are *spirally* marked on their inner surface, but in this case the markings are themselves the thickened part of the cell-wall. It is convenient to speak of the mixture of woody and vascular tissue as the *fibro-vascular system.*

Fig. 106.

The name *parenchyma* is commonly applied to ordinary cellular tissue, whilst tissue formed of long cells is called *prosenchyma*.

It will be understood, then, that all cells of every description, found entering into the composition of a plant, are only modifications of one original form, the particular form ultimately assumed by the cells depending mainly on the functions to be discharged by that portion of the plant in which the cells occur.

EXOGENOUS AND ENDOGENOUS STEMS.

163. It has already been hinted that the two great classes of plants, Dicotyledons and Monocotyledons, differ in the mode of growth of their stems. We shall

now explain somewhat more in detail the nature of this difference. Bearing in mind the fact stated in the preceding part of the chapter, that old and new parts differ mainly in the shape of their component cells and the texture of the cell-walls, it will be found that the distinction between Exogenous and Endogenous growth depends mostly upon the relative situation of the new cells and the old ones—of the *parenchyma* and the *prosenchyma*.

169. Let us begin with the stem of a Dicotyledon. Fig. 167 shows a section of a young shoot. The whole of the white part is cellular tissue, the central portion being the *pith*. The dark wedge-shaped portions are fibro-vascular bundles, consisting mainly of woody tissue, a few *vessels*, easily recognised by their larger openings, being interspersed. As the shoot becomes older, these bundles enlarge, and others are formed between them, so that the radiating channels of cellular tissue which separate them are in the end reduced to much smaller compass than in the earlier stages of growth (Fig. 168). The narrow channels are the *medullary rays*. The cells of which they are composed are flattened by compression. Eventually, a *ring* of wood is formed, the medullary rays intersecting it in fine lines, as the sawed end of almost any log will show. Outside the zone of wood is the *bark*, which at first consists altogether of cellular tissue. As the season advances,

Fig. 167.

Fig. 168.

however, long *bast* cells are formed in the *inner* part, next the wood, which part is thereafter specially designated the *liber*. The outer ring of all, enclosing the whole stem, is the *epidermis* or *skin*.

170. It is now to be observed that, year after year, the rings of wood are increased in thickness *by the multiplication of their outer cells.* There is, consequently, *always* a layer of soft cells between the wood and the bark. This is known as the *cambium layer*, and it is here that the whole growth of an exogenous stem takes place. The soft cells on its inner side are gradually transformed into woody tissue and vessels, whilst those on its outer side become the bast cells of the liber, and others form the extension of the medullary rays.

Bear in mind, then, that the exogenous stem is characterized (1) by the formation of its wood in rings, (2) by the presence of the continuous cambium-layer, and (3) by the presence of a true bark.

171. Let us now consider the structure of an endogenous stem. Fig. 169 represents a section of one.

Fig. 169.

Here, again, the white portion is cellular tissue, whilst the dark parts are the fibro-vascular bundles. This stem is at once distinguished from the other by the isolation of these bundles. They never coalesce to form a ring. That portion of each bundle, which is nearest the centre of the stem, corresponds to the wood of the exogen, whilst the outer portion of each consists of cells which resemble the exogenous bast-cells, but *there*

is no cambium-layer, and consequently no arrangement for the indefinite continuance of the growth of the bundles. Once formed, therefore, they remain unchanged, and the growth of the stem consists in the production of new ones. These (which originate at the bases of new leaves) being introduced amongst the older ones, act as wedges, and swell the stem as a whole.

THE FOOD OF PLANTS.

172. A word or two is necessary on this subject in addition to what has already been said. The nature of a plant's food may be determined by making a chemical analysis of the plant's substance. As already stated, the chemical elements found in plants are chiefly four, carbon, oxygen hydrogen and nitrogen, the latter element occurring in the protoplasm of active cells. What, then, are the sources from which the plant obtains these materials of its growth? In the atmosphere there is always present a gas known as carbon dioxide, or carbonic acid. This gas, which is a compound of carbon and oxygen, is produced largely in the lungs of animals, and by them exhaled. It is readily soluble in water, so the rain-drops in their passage through the air dissolve it and carry it with them into the soil. Again, wherever animal or vegetable matter is decaying there is produced a gas called ammonia, a compound of nitrogen and hydrogen, and like carbonic acid, readily soluble, so that this also is present in rain-water. And when it is considered that a very large proportion of the air consists of free nitrogen, soluble to some extent in water, and that the elements of water itself are oxygen and hydrogen it will be evident that the moisture in the earth contains a supply of every one of the elements

chiefly required by the plant. Now it is a matter of common experience that, with rare exceptions, a plant will wither and die unless supplied with adequate moisture. We therefore come to the conclusion, that at any rate the greater part of the nourishment of plants is imbibed in liquid form through the roots. The law of endosmose, in accordance with which this imbibing goes on, has already been explained. The *sap*, as it is called, ascends through the newer tissues, and is attracted to the leaves by the constant evaporation going on there, and the consequent thickening of the contents of the cells in those organs.

173. And this leads to the question—How does the water-vapour make its escape from the leaves? The microscope solves this difficulty for us. A leaf almost always presents one surface towards the sky and the other towards the ground. It is protected on both sides by an epidermis or skin, consisting of very closely packed cells. The side exposed to the sun is almost unbroken, but the lower side is seen, under the microscope, to be perforated by innumerable little openings, which lead into the body of the leaf. These openings, to which the name *stomata*, or *stomates* (Fig. 170) has been given, have the power of expanding when moistened by damp air, and contracting when dry. By this wonderful contrivance, the rate of evaporation is regulated, and a proper balance maintained between the supply at the root and the loss from the leaves. The stomates, it may be noticed, serve also as means whereby carbonic acid may be directly absorbed from the air. In those plants whose leaves float on water the stomates are

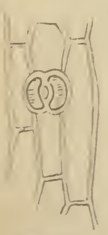

Fig. 170.

found on the upper surface, and in vertical leaves they occur pretty equally on both surfaces. Immersed leaves are without stomates.

174. The *crude sap*, then, which ascends into the leaves is concentrated by the evaporation of its superfluous water. When so concentrated, the action of sunlight, in connection with the green colouring matter existing in the cells of the leaves, and known as chlorophyll, decomposes the carbonic acid, contained in the sap, into its carbon and oxygen. The latter gas issues from the leaves into the air, whilst the carbon is retained and combined with the remaining elements to form *elaborated sap*, out of which the substance of new cells is constructed.

175. It thus appears that the chemical action which goes on in the leaves of plants is precisely the reverse of what takes place in the lungs of animals. The latter *inhale* oxygen, combine it with the carbon of the blood, and *exhale* the resulting carbonic acid. The former take in carbonic acid, decompose it in the leaves and other green parts, and *exhale* the oxygen. Plants may therefore be regarded as purifiers of the air.

176. It remains to be added, that besides the four substances, carbon, oxygen, hydrogen, and nitrogen, which are called the *organic elements*, many others are found in the fabric of plants. When a piece of wood is burnt away, the organic elements disappear, but a quantity of *ash* remains behind. This contains the various mineral substances which the water absorbed by the plant has previously dissolved out of the soil, but which it is not necessary to our present purpose to enumerate here.

CHAPTER XVI.

CLASSIFICATION OF PLANTS ACCORDING TO THE NATURAL SYSTEM.

177. Hitherto, our examination of plants has been confined to a few selected specimens, and we have examined these chiefly in order to become acquainted with some variations in the details of growth, as exemplified by them. Thus, we have found plants which agree in exhibiting two cotyledons in the embryo, and others, again, which are monocotyledonous. Some members of the former group were found to exhibit two sets of floral envelopes, other only one, and others, again, were entirely without these organs. And so on through the various details. We now set out with the vegetable world before us—a world populated by forms almost infinite in number and variety. If, therefore, our study of these forms is to be carried on to advantage, we shall have to resolve upon some definite plan or system upon which to proceed; otherwise we shall merely dissipate our energies, and our results will be without meaning. Just as, in our study of language, we find it convenient to classify words into what we call parts of speech, and to divide and subdivide these again, in order to draw finer distinctions, so, in our study of plants, it will be necessary to arrange them

first of all into comprehensive groups, on the ground of some characteristic possessed by every member of each group. Just as, in Latin, every noun whose genitive case is found to end in *æ* is classed with nouns of the first declension, so in Botany, every plant presenting certain peculiarities will be placed in a group along with all the other plants presenting the same peculiarities.

178. Some hints have already been given you as to the kind of resemblances upon which classification is based. For instance, an immense number of plants are found to produce seeds with a dicotyledonous embryo, while an immense number of others have monocotyledonous embryos. This distinction, therefore, is so pronounced, that it forms the basis of a division into two very large groups. Again, a very large number of dicotyledonous plants have their corollas in separate petals; many others have them united, whilst others again have no petals at all. Here, then, is an opportunity to subdivide the Dicotyledons into polypetalous, gamopetalous, and apetalous groups. And so we go on, always on the plan that the more widely spread a peculiarity is found to be, the more comprehensive must be the group based on that peculiarity; and so it happens, that the smallest groups of all come to depend upon distinctions which are, in many cases, by no means evident, and upon which botanists often find themselves unable to agree.

179. As our divisions and subdivisions will necessarily be somewhat numerous, we shall have to devise a special name for each kind of group, in order to avoid confusion of ideas. We shall, then, to begin with, draw a broad line of distinction between those plants

which *produce flowers* of some kind, and those which *do not*, and to each of these great groups we shall give the name Series. We thus have the Flowering, or, to use the Greek term, Phanerogamous, Series, and the Flowerless, or Cryptogamous, Series; or we may speak of them briefly as Phanerogams and Cryptogams. Then, leaving the Cryptogams aside for the moment, we may break up the Phanerogams into two great Classes, Exogens (or Dicotyledons) and Endogens (or Monocotyledons), for reasons already explained. By far the greater number of Exogens produce seeds which are enclosed in a pericarp of some kind; but there is a remarkable group of plants (represented in Canada only by the Pines and their immediate relatives) which dispense with the pericarp altogether, and whose seeds are consequently naked. So that we can make two Sub-Classes of the Exogens, on the basis of this difference, and these we shall call the Angiospermous Sub-Class, and the Gymnospermous (naked-seeded) Sub-Class. The first of these may be grouped in three Divisions, the *Polypetalous*, *Gamopetalous*, and *Apetalous*, and the Endogens also in three, the *Spadiceous*, the *Petaloideous*, and the *Glumaceous*, types of which we have already examined in the Marsh Calla (spadiceous), Trillium (petaloideous), and Timothy (glumaceous), and the distinctions between which are sufficiently obvious.

The Cryptogams are divided into three great Classes, viz.: Acrogens, embracing Ferns, Horsetails and Club-mosses; Anophytes, embracing Mosses and Liverworts; and Thallophytes, embracing Lichens, Seaweeds, and Mushrooms.

So far, then, our classification is as follows:

- VEGETABLE KINGDOM.
  - Series I. Phanerogams
    - Class I.—Exogens ...
      - Sub-class 1—Angiosperms
        - *Polypetalous Division.*
        - *Gamopetalous*
        - *Apetalous*
      - Sub-class 2-Gymnosperms
    - Class II.—Endogens
      - *Spadiceous Division.*
      - *Petaloideous Division.*
      - *Glumaceous Division.*
  - Series II. Cryptogams.
    - Class III.—Acrogens.
    - Class IV.—Anophytes.
    - Class V.—Thallophytes.

Each of the *Divisions* is sub-divided into a number of Families or Orders; each Order into a number of Genera; and each Genus into Species. A species is the sum of all the individual plants whose resemblances in all essential respects are so great as to warrant the belief that they have sprung from one common stock. De Candolle has this statement: "We unite under the designation of a *species* all those individuals that mutually bear to each other so close a resemblance as to allow of our supposing that they may have proceeded originally from a single being or a single pair." We may also speak of each one of these individual plants as a species. For example, you may say, after finishing the first lesson of this book, that you have examined *a species of Buttercup.* Mere differences of colour or size are not sufficient to constitute different species. The Balsams of our gardens, for instance, are of various colours, and the plants vary greatly in size, yet they all belong to one species. These minor differences, which are mainly the result of care and cultivation, give rise to *varieties.* These are of great interest to the horticul-

turist, but the study of *species* is the great end and aim of the botanist.

180. Those Species which are considered to resemble each other most nearly are grouped into Genera, and the Genera, in like manner, into Orders; but these particular groupings are more or less artificial, and are subject to continual alteration in consequence of our imperfect knowledge. As, year by year, new facts are brought to light, modifications in arrangement take place. In the Classification which constitutes the Second Part of this work, the Divisions spoken of above are placed in the order named. In the Polypetalous Division, those Orders are put first which embrace plants with *hypogynous stamens* and *apocarpous pistils*, the parts of the flowers being consequently *separate*; then those with similarly inserted stamens, but *syncarpous pistils*; then those with *perigynous* stamens; and, generally, we proceed from plants whose flowers have all their parts separate to those exhibiting more or less *cohesion* and *adhesion*, and finally to those having one or more parts of the flower wanting.

181. In looking up the name of a plant, it will be your object to determine the *Genus* to which it belongs, and also the *Species*. The name of every plant consists of two parts: its Genus first, and then its Species. The name of the Genus is a Latin noun, and that of the Species a Latin adjective agreeing with the noun. The Buttercup, for example, which we examined at the outset, belongs to the Genus *Ranunculus*. In this Genus are included many Species. The particular one examined by us is known as *acris*; so that the full name

of the plant is *Ranunculus acris*. In like manner, the name of the plant popularly called Marsh-Marigold is *Caltha palustris*.

182. The *Key* which is prefixed to the Classification will enable you to determine without much difficulty the *Order* to which a plant belongs, but nothing more. Having satisfied yourselves as to the Order, you must turn to the page on which that Order is described, and, by carefully comparing the descriptions there given with the characters exhibited by your plant, decide upon its Genus, and, in the same manner, upon its Species.

THE HERBARIUM.

Those who are anxious to make the most of their botanical studies will find it of great advantage to gather and preserve specimens for reference. A few hints, therefore, on this subject will not be out of place. It will, of course, be an object to collectors to have their specimens exhibit as many of their natural characters as possible, so that, although dried and pressed, there will be no difficulty in recognizing them ; and to this end neatness and care are the first requisites.

Specimens should be collected when the plants are in flower, and, if possible, on a dry day, as the flowers are then in better condition than if wet. If the plant is small, the whole of it, root and all, should be taken up ; if too large to be treated in this way, a flower and one or two of the leaves (radical as well as cauline, if these be different,) may be gathered.

As many of your specimens will be collected at a distance from home, a close tin box, which may be slung over the shoulder by a strap, should be provided, in which the plants may be kept fresh, particularly if a few drops of water be sprinkled upon them. Perhaps a better way, however, is to carry a portfolio of convenient size—say 15 inches by 10 inches—made of two pieces of stout pasteboard or thin deal, and having a couple of straps with buckles for fastening it together. Between the covers should be placed sheets of blotting paper, or coarse wrapping paper, as many as will allow the specimens to be separated by at least five or six sheets. The advantage of the portfolio is, that the

plants may be placed between the sheets of blotting paper, and subjected to pressure by means of the straps, as soon as they are gathered. If carried in a box, they should be transferred to paper as soon as possible. The specimens should be spread out with great care, and the crumpling and doubling of leaves guarded against. The only way to prevent moulding is to place plenty of paper between the plants,and *change the paper frequently*, the frequency depending on the amount of moisture contained in the specimens. From ten days to a fortnight will be found sufficient for the thorough drying of almost any plant you are likely to meet with. Having made a pile of specimens with paper between them, as directed, they should be placed on a table or floor, covered by a flat board, and subjected to pressure by placing weights on the top ; twenty bricks or so will answer very well.

When the specimens are thoroughly dry, the next thing is to mount them, and for this purpose you will require sheets of strong white paper ; a good quality of unruled foolscap, or cheap drawing paper, will be suitable. The most convenient way of attaching the specimen to the paper is to take a sheet of the same size as your paper lay the specimen carefully in the centre, wrong side up, and gum it thoroughly with a very soft brush. Then take the paper to which the plant is to be attached, and lay it carefully on the specimen. You can then lift paper and specimen together, and, by pressing lightly with a soft cloth, ensure complete adhesion. To render plants with stout stems additionally secure, make a slit with a penknife through the paper immediately underneath the stem ; then pass a narrow band of paper round the stem, and thrust both ends of

the band through the slit. The ends may then be gummed to the back of the sheet.

The specimen having been duly mounted, its botanical name should be written neatly in the lower right-hand corner, together with the date of its collection, and the locality where found. Of course only one Species should be mounted on each sheet; and when a sufficient number have been prepared, the Species of the same Genus should be placed in a sheet of larger and coarser paper than that on which the specimens are mounted, and the name of the Genus should be written outside on the lower corner. Then the Genera of the same Order should be collected in the same manner, and the name of the Order written outside as before. The Orders may then be arranged in accordance with the classification you may be using, and carefully laid away in a dry place. If a cabinet, with shelves or drawers, can be specially devoted to storing the plants, so much the better.

Wm Carter

Mitchell

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J Fred

INDEX AND GLOSSARY

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Abruptly pinnate, 114.
Absorption by roots, 2, 165, 172.
Acaulescent: apparently without a stem, 18.
Accessory fruits: such as consist chiefly of an enlargement of some organ, such as the calyx or receptacle, not organically united with the pistil, 151, 152.
Achenium or Achene, 156
Achlamydeous: having neither calyx nor corolla, 56
Acicular, Fig. 110.
Acrogens, 179.
Acuminate: with a long tapering point.
Acute: sharp-pointed, 110.
Adherent: a term applied to the union of unlike parts; *e. g.* stamens with corolla, &c.
Adnate (anthers), 132.
Adventitious: occurring out of the natural position.
Adventitious roots, 86.
Adventitious buds, 88.
Aerial roots, 86.
Aestivation: the folding of the floral envelopes in the bud.
Aggregate fruits, 150.
Air-plants (epiphytes), 87.
Albumen (of the seed): solid nourishing matter distinct from the embryo, 12.
Albuminous seeds, 59.
Alternate (leaves), 99.
Ament or Catkin, Figs. 63, 64.
Amplexicaul: clasping a stem.
Anatropous: a term applied to ovules when inverted, so that the micropyle is close to the point of attachment.
Andrœcium: the circle of stamens collectively, 132.
Androus: an ending of adjectives descriptive of stamens, *e.g.*, monandrous, polyandrous, &c.
Angiospermous: applied to plants whose seeds are enclosed in an ovary.
Annual: a plant which grows from the seed, flowers, and dies, in the same season.
Anophytes, 179.
Anther: the essential part of a stamen, containing the pollen, 132.
Apetalous: without a corolla; having only one set of floral envelopes, 20

Apocarpous: applied to pistils when the carpels are free from each other.
Appendage: anything attached or added.
Appressed: in contact, but not united.
Aquatic: growing in the water, whether completely, or only partially, immersed.
Arborescent: resembling a tree.
Aril, 157.
Arrow-shaped, Fig. 120.
Ascending: rising upward in a slanting direction; applied chiefly to weak stems.
Ascending axis: the stem of a plant.
Ascidium: a pitcher-shaped leaf, Fig. 134.
Ashes of plants, 176.
Assimilation, 165.
Auriculate: same as *auricled*, having rounded lobes at the base; applied mostly to leaves.
Awl-shaped, Fig. 112.
Awn: a bristle, such as is found on the glumes of many Grasses, Barley for example.
Axil, 3.
Axile: relating to the axis.
Axillary: proceeding from an axil.
Axillary buds, 88.
Axillary flowers, 120.
Axis: the stem and root.

Baccate: like a berry.
Bark, 169.
Bast, 167.
Bearded: furnished with hairs, like the petals of some Violets, &c.
Bell-shaped, 130.
Berry, 149.
Biennial: a plant which grows from seed in one season, but produces its seed and dies in the following season.
Bifoliolate: having two leaflets.
Bilabiate: two-lipped, Fig. 142.
Bipinnate: twice pinnate, Fig. 132.
Bipinnatifid: twice pinnatifid, Fig. 123.
Blade: the broad part of a leaf or petal.
Bracts, 19, 125.
Bracteate: subtended by a bract.
Bractlets: secondary bracts growing on pedicels, 125.
Branches: growths from the sides of a stem, originating in axillary buds, 3.
Breathing-pores (stomates), 173.
Bud: an undeveloped stem or branch.
Bulb, 92.

Bulbiferous: producing bulbs.
Bulblets, 95.
Bulbous: like a bulb in shape.

Caducous, 128.
Calyx, 5.
Cambium layer, 170.
Campanulate, 130.
Capillary: fine and hair-like.
Capitulum: same as *head*, 122.
Capsule, 155.
Carina, or keel: the two coherent petals in the front of a flower of the Pea kind, Fig. 36.
Caryopsis, 156.
Carpel, 7.
Carpellary: relating to a carpel, *e.g.*, a *carpellary l af*, &c.
Cartilaginous: tough.
Catkin, Figs. 63, 64.
Caulescent: with an evident stem.
Caulicle: another name for the radicle.
Cauline: relating to the stem, *e.g.*, *cauline leaves*, &c., 4.
Cell: the hollow in the anther, which contains the pollen. See also 161.
Cell-multiplication, 164.
Cellular tissue, 162.
Cellulose, 163.
Centrifugal inflorescence, 121.
Centripetal inflorescence, 120.
Chalaza: the part of an ovule where the coats are united to the nucleus.
Chlorophyll, 163, 174.
Ciliate, 116.
Circinate: curled up like the young frond of a Fern.
Circulation in cells, 163.
Circumcissile: opening like a pyxis, Fig. 161.
Classification, 177.
Claw (of a petal), 40, 129.
Climbing stems, 90.
Club-shaped: with the lower part more slender than the upper, as the style of Dog's-tooth Violet, Fig. 73.
Cohesent: a term applied to the union of like parts, 26.
Cohesion, 26.
Collerm, or neck: the junction of the stem and root.
Collactive fruits, 153.
Column, 72.
Coma: a tuft of hairs, such as that on the seed of Dandelion, Fig. 56.
Complete, 8.
Compound, or Composite, flowers, 49.

Compound leaf, 100.
Compound spike, corymb, &c., 122.
Cone, 143.
Coniferous: bearing cones.
Connate: grown together.
Connate-perfoliate, Fig. 130.
Connective, 132.
Convolute: rolled inwards from one edge.
Cordate, 108.
Corm, 66.
Corolla, 5.
Corymb, Fig. 135.
Corymbose: like a corymb.
Cotyledons, 58.
Creeping, 90.
Crenate, Fig. 128.
Cruciform: cross-shaped, as the flowers of Shepherd's Purse, &c.
Crude sap, 174.
Cryptogams, 179.
Culm, 90.
Cuneate: wedge-shaped.
Cuspidate, Fig. 126.
Cyclosis, 163.
Cyme, 124.
Cymose: like a cyme.

Decandrous: with ten separate stamens.
Deciduous 5.
Decompound: applied to leaves whose blades are divided and subdivided.
Decumbent: applied to stems which lie on the ground but turn upward at the extremity.
Decurrent, Fig. 131.
Decussate: applied to the arrangement of leaves, when successive pairs of opposite leaves are at right angles, as in the plants of the Mint family.
Definite inflorescence, 121.
Deflexed: bent down.
Dehiscent, 147.
Dehiscence of anthers, Figs. 147, 148, 149.
Deliquescent: applied to stems which dissolve into branches.
Deltoid, 146.
Dentate, 112.
Depauperate: unnaturally small.
Depressed: flattened down.
Descending axis: the root, 83.
Determinate inflorescence, 121.
Diadelphous: applied to stamens, 36.
Diandrous: with two separate stamens.

Dichlamydeous: having both sets of floral envelopes.
Dicotyledonous, 58.
Dicotyledons, 59.
Didynamous (stamens). 50
Digitate, 101.
Diœcious, 56.
Disk: in flowers of the Composite Family, the centre of the head as distinguished from the border; a fleshy enlargement of the receptacle of a flower.
Dissected: finely cut.
Dissepiment, 139.
Distinct: not coherent, (see Coherent).
Divergent: separating from one another.
Dodecandrous: with twelve distinct stamens.
Dorsal suture, 138.
Dotted ducts, Fig. 166.
Double flowers: abnormal flowers in which stamens and carpels have been transformed into petals.
Downy: covered with soft hairs.
Drupe, 147.
Drupelet, a little drupe.
Ducts, 167.

Earthy constituents of plants, 176.
Elaborated sap, 174.
Elementary constituents of plants, 176.
Elementary structure, 160.
Elliptical: same as oval, 105.
Emarginate, 111.
Embryo, 12.
Embryo-sac, 16.
Emersed: raised above the surface of water.
Endocarp: "When the walls of a pericarp form two or more layers of dissimilar texture, the outer layer is called the *Epicarp*, the middle one *Mesocarp*, and the innermost *Endocarp*."—*Gray*.
Endogen, 81.
Endogenous growth, 171.
Endosmose, 172, 165.
Enneandrous: with nine distinct stamens.
Entire, 112.
Ephemeral: lasting one day only.
Epicalyx, 33.
Epicarp: see Endocarp.
Epidermis, 160.
Epigynous: inserted on the ovary, 46.
Epipetalous: inserted on the corolla, 47.
Epiphytes, 87.
Equitant (leaves), 98.

Essential organs, 17.
Evergreen : retaining foliage during winter.
Exalbuminous, 59.
Excurrent: said of main stems which are distinct, and well-marked to the top, as in the Pine and Fir; the reverse of deliquescent.
Exhalation, 175, 173.
Exogen, 60.
Exogenous growth, 169.
Exserted protruding, 136.
Exstipulate, 115.
Extrorse, 132.

Fascicle: a close bundle, either of leaves or flowers.
Fascicled roots, 85.
Feather-veined: same as pinnately-veined, 101.
Fertile flower, 53.
Fertilization, 17.
Fibrous thread-like, 2.
Fibro-vascular system, 167.
Filament, 6.
Filiform, 117.
Fimbriate: fringed.
Fleshy fruits, 148.
Flora: a description of the plants of a district; a collective name for the whole of the species of a district.
Floral envelopes, 14.
Floret, 48.
Flower: the part of a phanerogamous plant in which the stamens and pistil are situated.
Flower-leaves, 11.
Flowering plants, 179.
Flowerless plants, 179.
Foliaceous: like a leaf in appearance.
Foliolate: having leaflets.
Follicle, 154.
Free, 5.
Fruit, 144.
Fugacious: falling away early.
Funiculus, 157.
Funnel-shaped, Fig. 140.
Furcate: forked.
Fusiform: same as spindle-shaped, 85.

Galea: an arching petal or sepal, as the two upper ones in Catnip, Fig. 57.
Gamophyllous, 63.
Gamopetalous, 129.
Gamosepalous, 127.

Genera: plural of genus.
Genus, 179.
Germ: same as embryo.
Germination, 158.
Gibbous: swollen on one side.
Glabrous, 116.
Gladiate: sword-shaped.
Glands: applied generally to cells or hairs on the surfaces of plants, in which resinous or oily matters are secreted; but the term is also used to describe any projection, the use of which is not clear.
Glandular: bearing glands.
Glaucous, 116.
Globose: like a globe or sphere.
Glumaceous: bearing or resembling glumes.
Glumes, 75.
Gourd, 149.
Grain, 156.
Granules: particles.
Gymnospermous, 143.
Gymnosperms, 179.
Gynœcium, 137.
Gynandrous, 135.

Habitat: a term applied to the region most favourable to the growth of a plant: the place where it grows naturally.
Hairs, 116.
Hairy, 4.
Halberd-shaped, Fig. 119.
Hastate. Fig. 119.
Head, 122.
Heart-shaped, 108.
Heptandrous: with seven distinct stamens.
Herb, 89.
Herbaceous, 89.
Herbarium: a botanist's collection of dried plants.
Hexandrous: with six distinct stamens.
Hilum, 157.
Hirsute: rough with hairs.
Hispid: covered with stiff hairs.
Hoary: densely covered with fine grayish hairs
Hortus siccus: same as herbarium.
Hybrids: plants resulting from the crossing of nearly related species.
Hypogynous, 135.

Imbricate: overlapping like shingles on a roof.
Immersed: wholly under water.
Imperfect, 53.

Included, 136.
Incomplete, 19.
Incurved (petals) Fig. 50.
Indefinite, 26, 134.
Indefinite inflorescence, 120.
Indehiscent, 147.
Indeterminate inflorescence, 120.
Indigenous: naturally growing in a country.
Inferior: underneath; farthest from the axis; the ovary is inferior when the calyx adheres to it throughout; the calyx is inferior when free from the ovary.
Inflorescence, 119.
Innate, 132.
Inserted: attached to.
Insertion: the point, or manner, of attachment.
Internodes, 4.
Interruptedly pinnate, Fig. 133.
Introrse, 132.
Involucel, 125.
Involucre, 125.
Involute: rolled inwards from both edges.
Irregular, 35.
Isomerous: having the parts equal in number.

Joints: a name sometimes given to the nodes of a stem.

Keel, see Carina.
Kernel, 16.
Key-fruit, 156.
Kidney-shaped, Fig. 121.

Labellum (or lip), 71.
Labiate, 50.
Lanceolate, Fig. 113.
Leaf, 97.
Leaf-arrangement, 99.
Leaf-green, see Chlorophyll.
Leaflet, 100.
Leafstalk, 4.
Legume, 154.
Leguminous: producing or relating to legumes.
Liber, 169.
Ligneous: woody.
Ligulate, 131.
Ligule: a strap-shaped corolla n Grasses, a scale-like projection between the blade of a leaf and the sheath.
Limb, 129, 130.
Lip, see Labellum.
Linear, Fig. 111.

Lobe, 4, 100.
Loculicidal (dehiscence) : splitting midway between the partitions.
Loment : a jointed legume.
Lyrate: pinnately-lobed, with the terminal lobe much larger than the others.

Marcescent: withering persistent.
Marginal: relating to the margin.
Markings (on cells), 167.
Medullary rays, 169.
Membranous : thin, like a membrane.
Mesocarp: see Endocarp.
Micropyle, 16.
Midrib, 101.
Monadelphous, 134.
Monandrous: with a single stamen, 72.
Monochlamydeous: with only one set of floral envelopes.
Monocotyledonous, 80.
Monocotyledons, 81.
Monœcious, 53.
Morphology, 82.
Mucronate, 110.
Multifid, 109.
Multiple fruits, 153.

Naked flowers: those which are destitute of calyx and corolla.
Naked seeds. those not enclosed in an ovary, 143.
Napiform, 85.
Natural system of classification, 177, &c.
Naturalized: introduced from other countries, but growing spontaneously from seed.
Neck, see Collum.
Nectary: that in which nectar is secreted.
Needle-shaped, Fig. 110.
Net-veined, 4.
Neutral flowers: those having neither stamens nor pistil.
Nodding: hanging with the top downwards, like the flower in Fig. 72.
Node, 4.
Normal: regular; according to rule.
Nucleus (of an ovule), 16, 157; (of a cell), 163.
Nut, 156.
Nutlet: a small nut, or nut-like body, 50.

Obcordate, 108.
Oblanceolate, 107.
Oblique: having the sides unequal.
Obliteration (of partitions), 140.
Oblong, 105.

Obovate, 107.
Obtuse, 110.
Ochrea: a tube formed by the union of both edges of a pair of stipules.
Ochreate: having ochreæ.
Octandrous: having eight separate stamens.
Offset: a short, prostrate branch, rooting at the end.
Opposite, 99.
Orbicular, 105.
Orders, 179.
Organic elements, 176.
Organs: the parts or members of a living body.
Organs of Reproduction: the parts of the flower.
Organs of Vegetation: root, stem, and leaves.
Orthotropous: applied to ovules when straight, so that the micropyle is as far as possible from the point of attachment.
Oval, 105,
Ovary, 7.
Ovate, 106.
Ovoid: egg-shaped.
Ovule, 7.

Palate, 131.
Palet, 75.
Palmate, 101.
Palmately-lobed, 109.
Palmatifid, 109.
Panicle, 123.
Papilionaceous, 35
Pappose, 128.
Pappus: a circle of bristles or hairs representing the limb of the calyx in flowers of the Composite Family, 48.
Parallel-veined: same as straight-veined, 62.
Parasites, 87.
Parenchyma, 167.
Parietal: on the walls, 141.
Parted: almost completely cut through.
Pectinate: pinnatifid with lobes like the teeth of a comb.
Pedate, Fig. 125.
Pedicel, 27.
Peduncle, 5.
Peltate, Fig. 123.
Pentandrous: with five distinct stamens.
Pepo, 149.
Perennial: a plant which continues to grow year after year.
Perfect: having both stamens and pistil.
Perfoliate, 113.
Perianth, 63.
Pericarp, 145.

Perigynous, 36.
Persistent, 32.
Personate, 131.
Petal, 5.
Petiolate: having petioles.
Petiole, 4.
Phanerogamous or Phænogamous, 179.
Pilose: having long soft hairs.
Pinna: a primary division of a pinnately compound leaf.
Pinnate, 101.
Pinnately-lobed, 109.
Pinnatifid, 109.
Pinnule. a secondary division of a pinnately compound leaf.
Pistil, 137, 7.
Pistillate: having a pistil, 53.
Pitcher-shaped (leaf), Fig. 134.
Pith, 169.
Placenta, 141.
Placentation, 141.
Plumose: feathery.
Plumule, 58.
Pod: a dehiscent fruit.
Pollen, 6.
Pollen-tube, 16.
Pollinia: pollen-masses, Fig. 87.
Polyadelphous, 134.
Polyandrous: with numerous distinct stamens.
Polycotyledonous, 159.
Polygamous: having perfect as well as imperfect flowers.
Polypetalous: having separate petals.
Polysepalous: having separate sepals.
Pome, 148.
Posterior: next the axis.
Præfloration, see Æstivation.
Præfoliation: the disposition of leaves in the bud.
Prickles, 96.
Procumbent: lying on the ground.
Prosenchyma, 167.
Prostrate, 90.
Protoplasm, 163.
Pubescent: covered with fine down.
Punctate: having transparent dots, like the leaves of St. John's Wort.
Putamen, 147.
Pyxis, 155.

Quinquefoliolate: having five leaflets.

Raceme, 122.

Racemose: like a raceme.
Rachis: an axis.
Radiate, 101.
Radical: pertaining to the root.
Radical leaves, 4.
Radicle, 58.
Raphides, 163.
Ray: the marginal florets of a composite flower, as distinguished from the disk.
Receptacle, 8.
Recurved: curved backwards.
Reflexed: bent backwards.
Regular: with parts of the same size and shape.
Reniform, Fig. 121.
Reticulated: netted.
Retuse: slightly notched at the apex.
Revolute: rolled back.
Rhizome, 91.
Ribs, 101
Ringent, 131.
Root, 2, 83.
Root-hairs, 165.
Rootlet, 2.
Rootstock, 91.
Rotate, 130.
Rotation in cells, 163.
Rudimentary: imperfectly developed.
Rugose: wrinkled.
Runcinate: with teeth pointing backwards, as in the leaf Dandelion.
Runner, 90.

Sagittate, Fig. 120.
Salver-shaped, Fig. 141
Samara, Fig. 162.
Sap, 172, 174.
Sarcocarp: the flesh of a drupe.
Scabrous: rough.
Scandent: climbing.
Scape, 19.
Scar, 157
Scion: a young shoot.
Seed, 17, 157, 158.
Seed-vessel, see Ovary.
Sepal, 5.
Septicidal (dehiscence): splitting open along th partitions.e
Septum: a partition.
Series, 179.
Serrate, 112

Sessile, 4.
Setaceous: like a bristle.
Sheath: a tube surrounding a stem, 62.
Sheathing: surrounding like a sheath.
Shield-shaped, see Peltate.
Shoot: a newly formed branch.
Shrub, 89.
Silicle, 155.
Silique, 155.
Simple (leaves), 100; (pistil), 137.
Sinuate: wavy on the margin.
Solitary, 121.
Spadiceous, 179.
Spadix, 69.
Spathe, 69.
Spathulate, 107.
Species, 179.
Spike, 122.
Spikelet, a secondary spike.
Spindle-shaped, 85.
Spine, 96.
Spiral markings, 167.
Spores: the reproductive bodies in Cryptogams which correspond to the seeds of Phanerogams.
Spur, 131.
Stamen, 6, 132.
Staminate (flower): having no pistil, but only stamens.
Standard: the broad upper petal of a papilionaceous corolla.
Stem, 3, 88.
Stemless, 18.
Sterile (flower): having no pistil.
Stigma, 7.
Stigmatic: bearing the stigma.
Stipulate: having stipules, 115.
Stipule, 31, 115.
Stolon: a short branch which droops to the ground and takes root.
Stomate, 173,
Stone, see Putamen.
Stone-fruit, see Drupe.
Strap-shaped, see Ligulate.
Striate: marked lengthwise with lines or furrows.
Strobile: same as Cone.
Style, 7.
Sub-class, 179.
Subulate, Fig. 112.
Succulent: juicy; fleshy.
Sucker: an underground branch, at length emerging and forming a stem.

Superior, 7, 37, 44.
Suppression : absence of parts.
Suspended : hung from above.
Suture, 138.
Symmetrical, 42.
Syncarpous, 29.
Syngenesious, 47

Tap-root, 84.
Teeth (of calyx), 32.
Tendril, 90.
Terete : cylindrical.
Terminal : at the end of a stem or branch.
Ternate : in threes.
Testa, 157.
Tetradynamous, 28, 136.
Tetrandrous : having four distinct stamens.
Thalamiflorous : having the stamens inserted on the receptacle.
Thalamus : the receptacle.
Thread-shaped, see Filiform.
Throat (of calyx), 128.
Thorn, see Spine.
Thyrse, 123.
Tissue, 162.
Tomentose : woolly.
Toothed, see Dentate, 112.
Torus : same as receptacle.
Tree, 89.
Triadelphous, 134.
Triandrous : having three distinct stamens.
Triennial : lasting three years.
Trifoliolate : having three leaflets.
Truncate, 111.
Trunk : the main stem.
Tube, 34, 128,
Tuber, 91.
Tuberous : like a tuber.
Tunicated, 92.
Twining, 90.
Two-lipped, see Labiate, 50.

Umbel, 122.
Umbellet : a secondary umbel.
Unguiculate : having a claw.

Valvate : edge to edge, but not overlapping.
Valve, 41, 133, 147.
Valved : having valves.
Varieties, 179.

Vascular tissue, 167.
Veins : the finer parts of the framework of a leaf.
Venation, 101.
Ventral suture, 138.
Vernation, same as Præfoliation.
Versatile, 132.
Vertical leaves, 98.
Verticillate, 99.
Vessels, 167.
Villose, 116.

Wavy : with alternate rounded hollows and projections, 112.
Wedge-shaped : like a wedge, the broad part being the apex.
Wheel-shaped, see Rotate.
Whorl : a circle of three or more leaves at the same node.
Woody tissue, 167.

APPENDIX.

Selections from Examination Papers.

UNIVERSITY OF TORONTO.

1. Define suckers, stolons, offsets, runners, tendrils, thorns, and prickles, describing their respective origins and uses, and giving examples of plants in which they occur

2. What are the functions of leaves? Describe the different kinds of compound leaves.

3. What is meant by inflorescence? Describe the different kinds of flower-clusters, giving an example of each.

4. Mention and explain the terms applied to the various modes of insertion of stamens.

5. How are fruits classified? What are multiple or collective fruits? Give examples.

6. Relate the differences in structure between endogenous and exogenous stems. Describe their respective modes of growth.

7. What is the food of plants? how do they obtain it? and how do they make use of it?

8. Describe the component parts of a simple flower. How is reproduction effected?

9. Describe the anatomical structure of a leaf, and the formation and office of leaf-stomata.

10. Explain the consequences of flowering upon the health of a plant, and shew how these effects are remedied in different climates. What practical bearing has this upon horticulture?

11. Trace the development of a carpel from a leaf. Describe the different forms assumed by placentæ in

compound ovaries, and explain the origin of these variations.

12. Mention the principal modes in which pollen gains access to the stigma. What are hybrid plants, and how are they perpetuated?

13. Describe the anatomy of a leaf. What are stomata?

14. What is the placenta in a seed vessel? Describe the different modes of placentation. Shew how the varieties of placentation agree with the "altered-leaf theory" of the pistil.

15. Give the characters of the Compositæ. How is the order subdivided? Describe the composite flower, and mention some of the common Canadian examples of this order.

16. Give the peculiarities of Endogens in seed-leaf, leaf, and stem. Subdivide the class. Describe shortly the orders Araceæ and Gramineæ.

17. Describe the wall of a seed-vessel, and notice its varieties of form.

18. What is meant by the dehiscence of a capsule? Shew the different modes in which pods dehisce, and give examples of each.

19. Give the characters and orders of Gymnospermous Exogens.

20. Give the characters of Ranunculaceæ. Describe shortly some of the principal plants of the order.

21. Give some account of the *special forms* which the leaves of plants assume.

22. What are stipules? What their size and shape?

23. What is meant by Imperfect, Incomplete, and Unsymmetrical flowers respectively?

24. Describe Papilionaceous and Labiate corollas.

25. Write notes on Abortive Organs, Gymnospermous Pistil, and Pollen Granule.

26. Distinguish between the essential and non-essential materials found in plants, and notice the non-essential.

27. What is vegetable growth? Illustrate by a ref-

erence to the pollen granule in its fertilization of the ovary.

28. What is an axil? What is the pappus?

29. What are the cotyledons? What is their function, and what their value in systematic Botany?

30. Distinguish between Epiphytes and Parasites; Describe their respective modes of growth, and give examples of each.

31. What is the difference between roots and subterranean branches? Define rhizoma, tuber, corm, and bulb, giving examples of each. How does a potato differ botanically from a sweet-potato?

32. Describe the calyx and corolla; what modifications of parts take place in double flowers?

33. What is a fruit in Botany? Explain the structure of an apple, grape, almond, strawberry, fig, and pineapple.

34. What organs appear in the more perfect plants? In what two divisions are they comprised?

35. Weak climbing stems distinguished according to the mode in which they support themselves, the direction of their growth, the nature of their clasping organs.

36. Structure and parts of a leaf: What is most important in their study? Give the leading divisions, and mention what secondary distinctions are required in specific description?

37. Function of the flower: its origin: its essential and accessory parts: names of the circles and their component organs: circumstances which explain the differences among flowers.

38. Parts of the fully formed ovule and distinctions founded on their relative position.

39. Sub-kingdoms and classes of the vegetable kingdom.

SECOND CLASS TEACHERS' CERTIFICATES, PROVINCE OF ONTARIO.

1. Name the parts of the pistil and stamens of a flower and give their uses

2. What are Perennial plants? Describe their mode of life.

3. "There are two great classes of stems, which differ in the way the woody part is arranged in the cellular tissue." Fully explain this.

4. Describe the functions of leaves. How are leaves classified as to their *veining?*

5. Name and describe the organic constituents of plants.

6. Name the organs of reproduction in plants, and describe their functions.

7. Give, and fully describe, the principal parts of the flower.

8. What are the different parts of a plant? Describe the functions of each part.

9. State all the ways by which an Exogenous stem may be distinguished from an Endogenous.

10. Describe the functions of leaves. What is the cause of their fall in autumn? Draw and describe a maple leaf.

11. Name the different parts of a flower, and describe the use of each part. Draw a diagram showing a stamen and a pistil and the parts of each.

12. What is the fruit? Why do some fruits fall from the stem more easily than others?

13. Of what does the food of plants consist? In what forms and by what organs is it taken up, and how is it asssimilated? Name the substances inhaled and those exhaled by plants, and the uses of each in the economy of nature.

14. Describe fully (1) the plant in Vegetation; (2) the plant in Reproduction.

15. Describe Fibrous roots, Fleshy roots, and different kinds of Tap-root.

16. Describe the structure and veining of leaves.

17. "The nourishment which the mother plant provides in the seed is not always stored up in the embryo." Explain and illustrate.

18. Describe the various modes in which Perennials

"provide a stock of nourishment to begin the new growth."

19. Describe fully the organs of reproduction in a plant. Describe the process of germination.

20. What are the parts of a flower? Give illustrations by diagram, with a full description.

21. Name and describe the principal sorts of flowers.

22. What elementary substances should the soil contain for the nourishment of plants?

23. How are plants nourished before and after appearing above ground?

24. Tell what you know about the various forms of the calyx and the corolla.

25. Explain the terms Cotyledon, Pinnate, Rootstock, Filament, and Radicle.

26. Explain the terms Papilionaceous, Cruciferous, Silique, and Syngenesious; and in each case name a family in the description of which the term under consideration may be properly applied.

27. Give the characters of the Rose family.

28. Describe the various modes in which biennials store up nourishment during their first season.

29. Explain the meaning of the terms Sepal, Bract, Raceme, and Stipule. Describe minutely the Stamen and the Pistil, and give the names applied to their parts.

30. Are the portions of the onion, the potato, and the turnip which are capable of preservation through the winter, equally entitled to the name of roots? Give reasons for your answer.

FIRST CLASS CERTIFICATES.

1. What are the cotyledons? Describe their functions, &c. State their value in systematic botany.

2. Describe the difference in structure and modes of growth of exogenous and endogenous stems.

3. Describe the circulation in plants. "In the act of making vegetable matter, plants purify the air for animals." Explain this fully.

4. What are Phœnogamous plants ? Define Raceme, Corymb, Head, Panicle, Ament.

5. Give the characters of *(a)* The classes Exogens and Endogens ; *(b)* The Mint and Lily families.

6. To what family do the Cedar, Clover. Mustard, and Dandelion respectively belong ?

7. Why does a botanist consider the tuber of the potato an underground stem ?

8. Give the philosophical explanation of the nature of a flower considered as to the origin and correspondences of its different parts.

9. Draw a spathulate, an obcordate, a truncate, a palmately-divided and an odd pinnate leaf.

10. Explain the constitution of a pome or apple-fruit.

11. What organs appear in the more perfect plants, and in what divisions are they comprised ?

12. Give the function of the flower, its origin, and its essential and accessory parts.

13. Describe the nature and chief varieties of roots, and distinguish between them and underground stems.

14. " As to the Apex or Point leaves are Pointed, Acute, Obtuse, Truncate, Retuse, Emarginate, Obcordate, Cuspidate, Mucronate." Sketch these different forms.

15. " There is no separate set of vessels, and no open tubes for the sap to rise through in an unbroken stream, in the way people generally suppose." Comment on this passage.

16. The great series of Flowering Plants is divided into two *classes.* Describe these classes.

17. Give the chief characteristics of the order *cruciferæ* (Cress Family), and name some common examples of this order.

18. State the difference between definite and indefinite inflorescence, and give examples of the latter.

19. Of what does the food of plants consist ? in what form is it found in the soil ? How is it introduced into the plant ? What inference may be drawn respecting the culture of the plant ?

20. Distinguish weak climbing stems according to the mode in which they support themselves, the direction of their growth, and the nature of their clasping organs.

21. Name the three classes of Flowerless Plants, and give an example of each.

22. Explain the terms Spore, Capsule, Bract, Stipule, Albumen, and Epiphyte.

23. What are tendrils, and of what organs are they supposed to be modifications?

24. Give the characters of the Cress Family, and name as many plants belonging to it as you can.

25. Tell what you know about the minute structure and the chemical composition of vegetable tissue.

26. Describe the origin of the different kinds of placentas; and of the different parts of the fruit of the plum, the oak, and the maple.

27. Describe fully the process by which it is supposed that water is carried up from the roots of plants.

28. Give the meaning of the terms *stomate*, *indehiscent*, *thyrse*, *glume*, *pyxis*. Distinguish *epiphytes* from *parasites*.

29. Describe any plant you have examined; if you can, tabulate your description.

30. Name all the families of monopetalous dicotyledons which you remember, and give the characters of any one of them.

McGILL UNIVERSITY.

1. Describe the germination of a plant.

2. Explain the differences in the structure of the embryo.

3. Explain the functions of the Root.

4. Describe the structures in a leaf, and explain their action on the air.

5. Mention the several parts of the stamen and the pistil, and explain their uses.

6. Describe an Achene, a Samara, a Drupe and a Silique.

7. Describe the differences in the stems of Exogens and Endogens, and the relations of these to the other parts of the plant and to classification.

8. Explain the terms Genera, Species, Order.

9. What is an excurrent stem, an axillary bud, bud scales ?

10. Explain the terms *primordial utricle, parenchyma, protoplasm,* as used in Botany.

11. What are the functions of the nucleus in a living cell?

12. Explain the movements of the sap in plants.

13. Describe the appearance under the microscope of *raphides, spiral vessels,* and *disc-bearing wood-cells.*

14. Describe the structure of the bark of an Exogen.

15. Describe freely the anatomy of a leaf.

16. Describe shortly the parts and structures denoted by the following terms, *spine, aerial root, phyllodium, cambium, stipule, rhizoma.*

17. Give examples of *phænogams. cryptogams, exogens* and *endogens,* properly arranged.

18. Describe the principal forms of indeterminate inflorescence.

19. In what natural families do we find *siliques, didynamous stamens, labiate corollas,* or *pappus-bearing achenes.* Describe these structures.

20. State the characters of any Canadian Exogenous Order, with examples.

21. Describe the cell-walls in a living parenchymatous cell.

22. Describe the fibro-vascular tissues in an Exogenous stem.

23. Describe the appearance of stomata and glandular heirs under the microscope.

24. Define *prosenchyma, corm, cyclosis, thallus.*

25. Explain the sources of the Carbon and Nitrogen of the plant, and the mode of their assimilation.

26. Describe the pericarp, stating its normal structure, and naming some of its modifications.

27. Explain the natural system in Botany, and state the gradation of groups from the species upward, with examples.

ONTARIO COLLEGE OF PHARMACY.

1. What do plants feed upon ?

2. What do you understand by the terms Acaulescent, Apetalous, Suffrutescent, Culm ?

3. Name some of the different forms of Primary, Secondary, and Áerial Roots, giving examples.

4. Explain the following terms descriptive of forms of leaves, giving sketch :—Ovate, Peltate, Crenate, Serrate, Cleft, Entire, Cuspidate, Perfoliate.

5. Explain difference between Determinate and Indeterminate inflorescence, giving three examples of each.

6. What organs are deficient in a sterile and a fertile flower ?

7. Give the parts of a perfect flower, with their relative position.

8. Give the difference between simple and compound Pistil, with example of each.

9. Name the principal sorts of buds, and explain how the position of these affects the arrangement of branches.

10. Give description of multiple and primary roots, with two examples of same ; also explain the difference between these and secondary roots.

11. Name the principal kinds of subterranean stems and branches, and explain how you would distinguish between these and roots.

12. In the classification of plants explain difference between classes and orders : genus and species.

13. Name three principal kinds of simple fruit.

14. When roots stop growing does the absorption of moisture increase or decrease ? Give reason for it.

15. Upon what do plants live ? Indicate how you would prove your answer correct.

16. In what part of the plant, and when, is the work of assimilation carried on ?

17. Name three principal kinds of *determinate*, and some of *indeterminate* inflorescence ; name the essential organs of a flower.

18. In what respects do plants differ from inorganic matter? And from animals?

19. Describe a Rhizome, Tuber, Bulb; and say if they belong to the root or stem; which are Rheum, Jalapa, Sweet Potato, Onion?

20. Define the difference between natural and special forms of leaves; between simple and compound leaves. Give example of each. Sketch a connate-perfoliate leaf.

21. Mention the parts of an embryo. Of a leaf. Of a pistil. Of a stamen. Of a seed.

22. What is meant by an albuminous seed? By diœcious flowers? By a compound ovary?

23. What is the difference between determinate and indeterminate inflorescence? How do they influence growth of the stem? Give three principal kinds of each.

24. Name the parts of a flower. What office is performed by the ovule? Name two kinds.

25. Name the parts of a vegetable cell. What are spiral ducts?

26. In what parts of the plant is the work of absorption carried on? In what part the work of assimilation? How do plants purify the air for animals?

27. Explain the natural system of classification in Botany? Name and characterize the classes of plants.

28. Explain the structure and functions of the Leaf, Bud, Root.

29. Give some of the terms used in describing the shape of a simple leaf as concerns (*a*) its general contour, (*b*) its base, (*c*) its margin, (*d*) its apex.

30. Name the organs in a perfect flower; describe fully the structure of the anther and pollen. What is coalescence and adnation of the parts of a flower?

31. Explain the terms Raceme, Pappus, Coma, Rhizome, Pentastichous.

32. State the distinction between Exogens and Endogens.

33. What are cellular structures as distinguished from vascular? What is chlorophyll?

34. Mention the organs of fructification, and explain the process of fertilization in a flowering plant.

35. Explain the structure of a seed, and describe in a few words the process of germination.

36. Define what is meant by the following terms:—Morphology, Polycotyledonous, Epiphyte, Peduncle, Stipules.

37. Describe briefly the root stem, leaf, and flower of the common dandelion, giving the functions or office of each.

38. Name some of the most common forms of leaves, giving a few rough outlines.

39. Of what part of the flower does the fruit nominally consist? What additional parts are in some instances present?

40. Define the terms Drupe, Pollen, Gynandrous, Pome, Adnate.

41. Explain the process of fertilization in flowering plants, and mention the different ways in which it is brought about.

49. Enumerate the different varieties of tissue recognized by botanists, and give their situation in an Endogenous stem.

THE END.

Finis the end

Wm Jno Carter

Only where the chlorophyll.
that the sunlight has the power
of decomposing carbon . . .

Indeterminate Inflorescence

Raceme - a cluster in which each flower
springs from an axil & is
supported on a pedicel of its own
—Shepherd's Purse
Spike - If pedicels absent & flowers
sessile
—Mullein—
Corymb - if lower pedicels are long
so that flrs are nearly level
Head - when internodes of spike
are suppressed — Clover

Umbel

What occurs in the leaf of the plant is assimilat[illegible]

animals [illegible] [illegible]

[illegible]

Mrs. Wm. Carter

Mitchell

Ark.